DOCUMENT RESUME

ED 039 346 VT 010 968

TITLE	Farm Crop Production Technology: Field and Forage Crop and Fruit and Vine Production Options. A Suggested 2-Year Post High School Curriculum.
INSTITUTION	Office of Education (DHEW), Washington, D.C. Div. of Vocational and Technical Education.
REPORT NO	OE-81016
PUB DATE	Feb 70
NOTE	187p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (FS5.280:81016, $1.50)
EDRS PRICE	EDRS Price MF-$0.75 HC Not Available from EDRS.
DESCRIPTORS	*Agricultural Education, *Agricultural Production, *Agricultural Technicians, Bibliographies, *Curriculum Guides, Educational Facilities, Farm Management, Farm Occupations, Field Crops, Post Secondary Education, *Program Guides
IDENTIFIERS	Forage Crops, Fruit Production, Vine Production

ABSTRACT

Prepared by a junior college under contract with the Office of Education, the curriculum materials are designed to assist school administrators, advisory committees, supervisors, and teachers in developing or evaluating postsecondary programs in farm crop production technology. Information was gathered by visits to the important farm regions and to outstanding schools with technician programs, and consultations with teachers, administrators, and representatives of private business and farming. Included in the guide are: (1) suggested course outlines with course descriptions and examples of texts and references, (2) information on the sequence of technical education procedure, (3) laboratory layouts with equipment and cost, (4) discussion of land requirements, (5) sections on the library and its use, the faculty, and student selection and services, (6) a selected list of scientific, trade, and technical societies, (7) summary of costs for the curriculum options, and (8) a bibliography. Curriculum outlines and course descriptions are provided for the Field and Forage Crop Production and the Fruit and Vine Production options. Course outlines are included for: (1) Technical Specialty Crops, (2) Auxiliary and Supporting Technical Courses, (3) Mathematics and Science Courses, and (4) General Courses. A selected list of professional and technical societies and organizations concerned with crop and fruit production is appended. (SB)

ED0 39346

OE–81016

FARM CROP PRODUCTION TECHNOLOGY: Field and Forage Crop and Fruit and Vine Production Options

BAVLP
same
BAVTE

A Suggested 2-Year Post High School Curriculum

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education
ROBERT H. FINCH, *Secretary*
JAMES E. ALLEN, JR., *Assistant Secretary and Commissioner of Education*

FOREWORD

THIS SUGGESTED curriculum was prepared to aid in planning and initiating programs in the States to meet the growing need for highly qualified farm crop production technicians to fulfill present requirements, and to prepare future farmowners and operators to cope with continued technological change.

The guide provides suggested course outlines with examples of texts and references, sequence of technical education procedure, laboratory layouts with equipment and cost, discussion of land requirements, library and its use, faculty, student services, and a selected list of scientific, trade, and technical societies. It is designed to assist school administrators, advisory committees, supervisors, and teachers who will be developing or evaluating programs in farm crop production technology. Although the indicated level of instruction is post high school, the sequence of course work may well start at any grade level where students have the prerequisite background and understanding.

This guide was developed in the Program Development Branch of the Division of Vocational and Technical Education, U.S. Office of Education. The basic materials were prepared by Mount San Antonio Junior College at Walnut, Calif., pursuant to a contract with the Office of Education.

Many useful suggestions were received from special consultants, advisers, owners, and employers in the farm crop production industry, and administrators and teachers in schools of technology. Although all suggestions could not be incorporated, each was considered carefully in the light of the publication's intended use. In view of this it should not be inferred that the curriculum is completely endorsed by any one institution, agency, or person. It is a plan for a program; a plan to be modified by administrators and their advisers to meet local, State, and regional needs.

LEON P. MINEAR
Division of Vocational and
Technical Education

GRANT VENN
Associate Commissioner for
Adult, Vocational, and
Library Programs

August 15, 1969

ACKNOWLEDGMENTS

THE U.S. OFFICE OF EDUCATION, Division of Vocational and Technical Education, recognizes the valuable contributions made in the detailed review of this publication by the following individuals:

Stuart Baker, director, Washington Operations, J. I. Case Co., 1000 16th Street NW., Washington, D.C. 20036.

Max E. Benitz, Rural Route No. 2, Prosser, Wash. 99350, president, Washington State Farm Bureau, member, Washington State Coordinate Council for Education.

Robert V. Call, Jr., 8113 Lewiston Road, Batavia, N.Y. 10402, president, New York State Vegetable Growers Association, member of Governor Rockefeller's Commission for Preservation of Agriculture Lands.

Robert C. Kennedy, supervisor, Plant Science Technician Curriculum, Thompson School of Applied Science, University of New Hampshire, Durham, N.H. 03824.

Hubert V. Kiehl, Malta Bend, Mo. 65339, member of Missouri Farm Bureau, Board of Directors, Contract Seed Grower.

Donald F. McMillen, assistant general manager, Sunkist Grower, Inc., Post Office Box 2706, Terminal Annex, Los Angeles, Calif., owner and operator, with tenant, of a small Illinois grain farm.

Harold R. Peck, crops instructor, Mount San Antonio College, 1100 Grand Avenue, Walnut, Calif. 01789.

Robert F. Reimers, Reimers Seed Farm, Rural Route No. 3, Box N 40, Carrington, N. Dak.; chairman, State Budget Board of North Dakota Legislature.

G. Allen Sherman, dean of Agricultural Science, Mount San Antonio College, Walnut, Calif. 91789; project manager for contract for this curriculum.

Howard Sidney, chairman of Agricultural Division, Agricultural & Technical College, State University of New York, Cobleskill, N.Y. 12043.

John W. Talbott, director, Farm Crops (California Region) Cargill, Inc., West Sacramento, Calif. 95691.

The Office of Education also acknowledges with appreciation the con-

structive criticism by administrators and staff members of the following institutions:

Abraham Baldwin Agricultural
College
Tifton, Ga. 31794

Agway Inc.
Syracuse, N.Y. 13201

Murray State College
Tishomingo, Okla. 73460

Northeastern Junior College
Sterling, Colo. 80751

Penta County Vocational School
and Technical College
Perrysburg, Ohio 43551

Purdue University
Lafayette, Ind. 47905

San Joaquin Delta College
Stockton, Calif. 95204

State University of New York
Agricultural and Technical
College
Alfred, N.Y. 14802

State University of New York
Agricultural and Technical
College
Farmingdale, N.Y. 11735

University of Nebraska
Curtis, Nebr. 69025

Wenatchee Valley College
Wenatchee, Wash. 98801

CONTENTS

Page

FOREWORD iii
ACKNOWLEDGMENTS iv
THE FARM CROP PRODUCTION TECHNOLOGY PROGRAM 1
  General Considerations 3
  Occupational Opportunities 4
  Special Abilities Required of Technicians in General 7
  Activities Performed by Technicians in Farm Crop Technology 7
  Faculty 8
  Student Selection and Services 10
  Textbooks, References, Visual Aids 12
  Library 13
  Laboratory Equipment and Facilities 14
  Advisory Committees and Services 15
  Scientific and Technical Societies and Trade Associations 16
THE CURRICULUM 18
  The Curriculum Outline for Field and Forage Crop Production Option 19
  The Curriculum Outline for Fruit and Vine Production Option 20
  Brief Descriptions of Courses for the Field and Forage Crop Production Option 21
  Brief Descriptions of Courses Unique to the Fruit and Vine Production Option 23
  Curriculum Content and Relationships 23
  Cooperative Education Plan 25
  Suggested Continuing Study 26
COURSE OUTLINES 28
  Technical Specialty Courses 28
    Cereal Crops 28
    Deciduous Fruit Production 33
    Field Crops 36
    Forage Crops 39
    Fruit Processing 48
    Grassland Management 56
    Plant Diseases and Pests 62
    Plant Propagation 67
    Seed Production 71
    Small Fruit Production 78
    Soil Management 85
    Soil Science 90
    Subtropical Fruit Production 94
    Truck Crops 98
    Weeds and Weed Control 101
  Auxiliary and Supporting Technical Courses 108
    Agricultural Mechanics 108
    Crop Marketing 110
    Farm Machinery 112
    Farm Management 115

Page

  Farm Power 118
  Farm Records and Reports 120
  Irrigation and Water Management 123
 Mathematics and Science Courses 126
  Mathematics I 126
  Mathematics II 128
  Agricultural Chemistry 129
  Crop Botany 133
 General Courses 140
  Agricultural Economics 140
  Communications Skills 142
  Principals of Social Science 151
BUILDINGS, FACILITIES, EQUIPMENT, AND COSTS 156
 General Planning 156
 Land Requirements 157
 Building Facilities 157
 Planning the Laboratories 158
 Acquisition of Equipment, and Estimated Costs 161
 Suggested Audiovisual Equipment 163
 Suggested Laboratory Equipment 163
 Suggested Shop Equipment 165
SUMMARY OF COSTS 167
 Forage and Field Crop Option 167
 Fruit and Vine Production Option 167
 Both Options 168
BIBLIOGRAPHY 169
APPENDIX —
 Selected List of Professional and Technical Societies and Organizations concerned with Crop and Fruit Production 175

THE FARM CROP PRODUCTION TECHNOLOGY PROGRAM

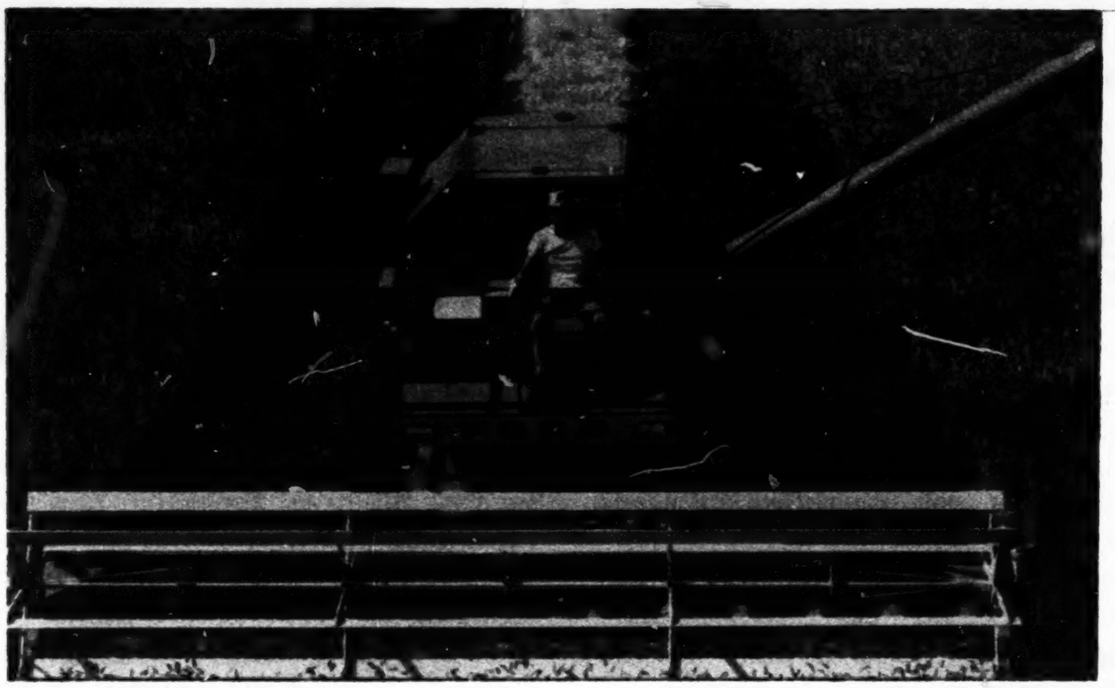

Figure 1.—Mechanized production of stable food crops of which this field of wheat is typical requires an understanding of modern agricultural technology.

FARM CROP production requires over 300 million acres of land in the United States today. An annual income of over $40 billion at the farm level comes from the sale of these crops along with the livestock produced from them. The American farmer today represents less than 10 percent of the population, yet produes enough food for himself and 40 other people. (1969)

This is contrasted with some moderately well-developed countries where often half or more of the population is engaged in farming, yet produces barely enough to meet national needs. In some underdeveloped countries, the population on farms is as high as 80 percent with food shortages still existing. The American farmer has learned to make use of the great number of changes in mechanization and to apply other technological advances in order to accomplish this tremendous production of food and fiber.

Farming in the United States has become a science, with production involving both life and physical sciences. This is combined with careful management as well as the use of sound business principles. Today's farmer is farming on ever increasing acreage per farm. This, coupled with more mechanization, has increased his need for capital. Today farmers are spending some $30 billion per year to pay the cost of producing the Nation's abundance of farm products. The investment per worker in agriculture is over $21,000 compared to about $16,000 per worker in most manufacturing industries. The farmer is no longer self-sufficient. He buys many of his production requirements, such as seed, fertilizer, and equipment. As a result, a large number of businesses have been established which are closely allied to farming.

The modern farmer now needs to know more than ever before about his crop after it leaves the farm and proceeds through marketing and processing channels. In some cases processing starts on the farm or with a marketing or processing organization in which the farmer has an interest. As each crop product goes through the marketing processes to the consumer, it

Figures 2.—The machinery and equipment shown here for picking dates reflects only some of the specialized technological factors involved in large-scale and efficient production of orchard and vineyard products.

must be tested, graded, transported, processed, packaged, and priced. Each of these activities has a direct bearing upon the income received by the farmer for his crop. Therefore, he needs to understand these processes.

Statistics show that there has been a decrease in the number of farmers in recent years. Since over one-third of the farmers in the United States today are more than 55 years of age, probably 30 or 40 percent will retire during the next 10 to 15 years. Even though all of the farmers who retire may not be replaced because other farmers may buy their land to increase their own acreage, there will still be a need for several hundred thousand new farmers and farm managers in the coming decade.

Figure 3.—Farm crop production technicians must learn many technical details and techniques associated with applied science in agriculture. This student selects seeds, identify foreign materials, and discern damage to a grain crop using modern equipment in a college laboratory.

As the size of farms increases with a corresponding decrease in the number of farmers, each new generation in farming must be better educated to meet the demands of modern farming. In addition, those working with the farmer in the service, supply, marketing, and processing businesses must be better educated to do the work required by the increased use of applied science and technology to all phases of farm production.

For all of these reasons, it has become apparent to many who are concerned with modern agriculture that a high school education is no longer sufficient for most farmers or for many workers in fields closely allied to farming. The problems of modern farming have become so technical that at least a 2-year post high school technical education program, or its equivalent, is rapidly becoming a necessity.

In the business of farm crop production, usually involving extensive land and capital, it is imperative that farmers be well educated. It is also imperative in the national interest if the United States is to maintain its leadership in world food production. Despite temporary surpluses in a few U.S. farm crops, experts on world food production predict that an increase of up to 25 percent in this Nation's crop production will be needed by 1975. To do this on the

Figure 4.—Much of the work in producing grapes in this modern vineyard is mechanized. The capital investment requires that it be a large-scale operation to be economical.

available acreage will call for maximum use of human resources in farming for the coming generation. This can be brought about by better education for our present and future farm owners, operators and workers.

This guide to programs to educate farm crop production technicians presents two options, each directed toward a major kind of farm crop production. When a program is established, the facilities and staff are also usually utilized to provide courses for graduates of the program in their continuing study, and for farmers and other employed adults who need to update and upgrade their technical knowledge.

Figure 5.—The fruit and vineyard crop technician applies many facets of biological and agricultural science in producing these grapes, 4 pounds of which are required to make 1 pound of raisins.

The *field and forage crop option* is designed to cover field crops, cereal crops, forage crops, and truck crops. In the areas where little intensive farming of row crops takes place, an elective is offered in grassland management. This post high school program prepares the student as a specialist in the production, harvesting, and marketing of these crops and provides him with a basic understanding in farm mechanics and basic sciences which are essential to successful crop production.

The *fruit and vine production option* is designed to cover both deciduous and subtropical fruits, nuts, berries, and grapes. This option is provided for those who wish to specialize in the production, harvesting, and marketing of these crops. The supporting courses in science, plant propagation, and fruit processing are designed to prepare the student in preproduction and postharvesting techniques and procedures.

Figure 6.—This field of lettuce illustrates how garden and vegetable crops have now become large field crops for which highly specialized culture procedures, tilling, and harvesting equipment have been developed.

General Considerations

This guide has been prepared for school administrators or department heads who are considering whether or not to establish post high school programs in crop or fruit and vine production, or who wish to strengthen an existing program. The program was formulated after extensive study including visits to most of the important farming regions of the United States and to outstanding schools which provide programs to educate technicians in these fields. Consultations with teachers, administrators, and representatives of private business and farming in each region explored problems, ideas, suggestions, and recommendations on many pertinent aspects of the program. All have shaped the content of this guide.

Institutions which establish programs using this guide will find that modifications can be made to fit the local conditions of their specific area. School administrators and teachers who wish to add or to delete courses or parts of courses should seek the advice of local advisory committees so the resulting program will meet local or regional needs. A program of this type should not be undertaken without most of the recommended facilities and equipment and the necessary staff. Even with the best facilities and equipment, highly effective teaching is necessary to make the program a successful one.

Those who believe a farm crop production technician program may be needed in their institution should begin with a comprehensive regional, State, and local study. It should be made with the help of people acquaintd with the agricultural needs in the area of crop or fruit production. Such a study is necessary to catalog the educational needs, to define the community support, to evaluate available student population, and to form a basis for a decision as to whether or not to offer the program. No program should be undertaken unless there is a strong indication that it will be needed for at least 10 years.

Some of the courses suggested in this program can be combined or eliminated entirely in adapting it to the agriculture of the area. Time made available by such an action may be used to extend or emphasize course content, or to introduce special courses to meet local needs. For example, in some States there is considerable demand for grain elevator managers. In those States it may be desirable to add courses in business and to combine such courses as cereal and field crops. Local advisory committees can be of great assistance in making such decisions.

Technical programs are offered in several types of post high school institutions in the United States. These are the 2-year community or junior colleges, technical institutes or colleges, area vocational and technical schools, or in a division of 4-year colleges or universities. The program outlined in this guide could be offered in any of these types of institutions.

Figure 7.—This corn harvester illustrates how machinery has substituted mechanical power for human and animal energy in the production of major agricultural crops.

Questions such as the following should be answered in the affirmative before the program should be undertaken:

(1) Is the program an educational objective which the administration and staff of the institution understands and will support with staff, money, and cooperation?
(2) Is the present faculty, if any, qualified; or can such staff be obtained?
(3) Will there be adequate financial support to provide the program with buildings and facilities and to maintain it by providing the proper tools, books, instruments, and equipment necessary for a high quality program?
(4) Will provisions be made for effective guidance and placement services?
(5) Will such a program meet a need in the State or community at a reasonable cost?

Occupational Opportunities

During the years since World War II, there has been a strong demand for technically trained people in agriculture and its related industries. This is the result of the technological changes which have taken place in agriculture. Until recently, most of the technical work has been done by graduates of the 4-year colleges. However, the demand for professionally trained people in agriculture has become so great that the 4-year colleges cannot meet all of the demands. The 4-year colleges have reported that for every graduate there are five to seven employment opportunities. The number is much larger in some specialized areas.

Many professional services in agriculture and related fields require education beyond the bachelor's degree. Some colleges of agriculture have as high as 50 percent of the students working on advanced degrees. Studies of 4-year college graduates show that only a relatively small percentage return to the farm.

Today, there is a need for workers who have enough technical knowledge to work with and to extend the effectiveness of the highly educated professional worker. A worker who can do this is the technician who has completed a high quality post high school preparatory program in the agricultural technology of his choice.

The program in this guide is designed for those who wish to take 2 years of farm production oriented education beyond the high school and go directly into farming or a closely related agricultural business. Experience has shown that employers in related businesses want employees who have a good technical agricultural preparation. For example, in agricultural sales, employers indicated that a good technical knowledge of agriculture was more important than sales ability. The nature of farmers as customers makes it desirable for the salesman to be able to "talk the language" and to show the farmer how the product will benefit his farming program or increase his farm income. If the salesman cannot do this, sales training alone will not make the salesman effective.

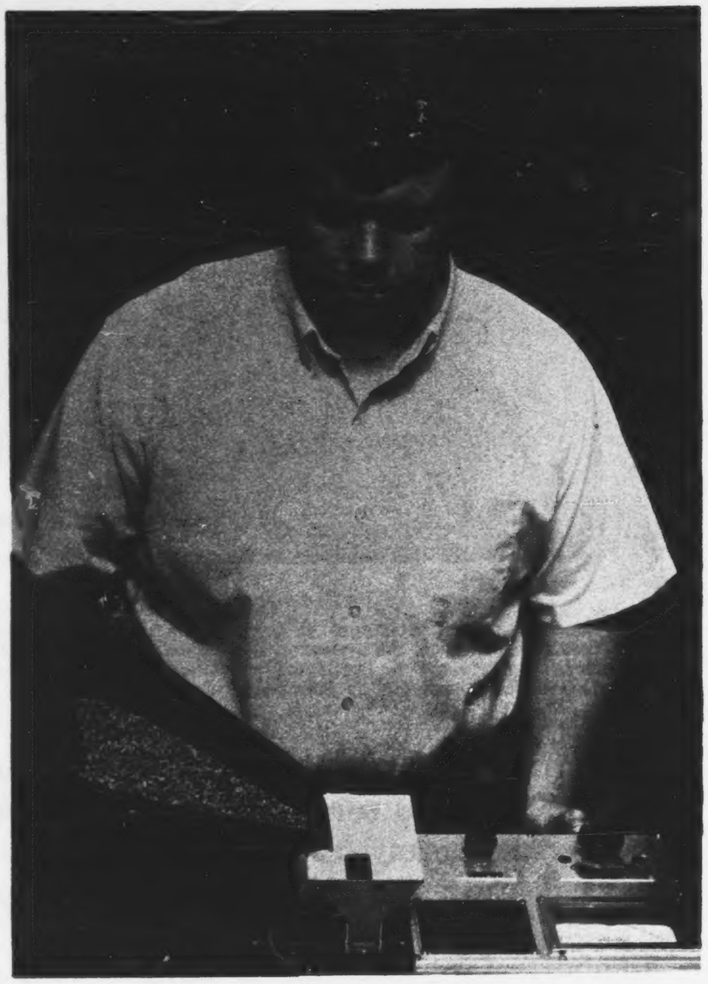

Figure 8.—Many employment opportunities off the farm are available for well-trained field and forage production technicians. Grain grading and inspection for moisture content shown here is one example of many inspection and marketing employment opportunities.

There are many employment opportunities that graduates of this program may choose in addition to farming. The list that follows has been checked by educators and by employers. They are in general agreement that these jobs are examples of work that graduates would be prepared to do at the entry level. The titles differ in some areas, and may be subject to change as work changes and new positions are created.

Typical Employment Opportunities — Field and Forage Crop Production Technology

Farm operator
Farm foreman or supervisor
Custom farm operator
Technical farm worker
Farm loan assistant
Seed processing foreman
Farm supply salesman
Farm cooperative employee
Hay and forage buyer and seller
Farm machinery foreman
Picking crew foreman
Fieldman, food processing company
Fieldman, produce firm
Packing shed foreman
Produce department manager
Grain inspector
Seed inspector
Vegetable inspector
Soil conservation aid
Research technician, U. S. Department of Agriculture

- Research technician, seed company
- Research technician, agricultural extension service
- Rodent control assistant
- Pest control assistant
- Pest control equipment specialist
- Peace Corps worker
- Technical assistant
- Technician, U.S. Agency for International Development

Typical Employment Opportunities—Fruit and Vine Production Technology

- Fruitgrower, deciduous
- Fruitgrower, subtropical
- Fruit nursery operator
- Fruit nursery worker (specialist)
- Vineyard foreman
- Vineyard worker (specialist)
- Custom farm operator
- Small fruitgrower
- Plant propagator
- Fieldman, fruit buying organization
- Fieldman, fruit processing organization
- Fruit processing plant operations specialist
- Packing shed foreman
- Picking crew foreman
- Fruit inspector
- Weed control assistant
- Spray equipment operator and specialist
- U.S. Department of Agriculture research assistant
- Research assistant, agricultural extension service
- Orchard equipment salesman
- Nursery salesman
- Spray material salesman
- Irrigation equipment salesman
- Fruit supply salesman
- Peace Corps worker
- Technical assistant
- Technician, U.S. Agency for International Development

Graduates of this program may be expected to enter the positions listed at the entry level. It is assumed in most cases they will advance on the job to higher positions as a result of experience and further study. After programs have become established, it is recommended that additional courses in applied agricultural sciences, farm management or finance, business or agricultural economics be offered. There should be inservice education available to the graduates and other interested adults in the evening or at times when they can take them without interfering with their work.

Some of the employment titles listed, such as farm worker, may not appear to require technical training. They do not refer to the "old time" hired hand but are examples of the increasing number of workers who may be called upon to do and/or to be responsible for specialized jobs in irrigation, fertilization, or pest control in today's farm crop production work.

Figure 9.—Modern citrus orchards such as this one are cultivated and cultured like field crops. Some of the orchard care operations may be contracted by the owners and performed by specialized agricultural service contractors who must be technically competent in their field.

This program is intended to provide the education of specialized personnel who are capable of performing many tasks requiring special skills, and who are confident in their abilities, education, competence and judgment.

Administrators planning to initiate such a program should be aware of the special abilities required of technicians and the nature of the tasks they may be called upon to perform.

Special Abilities Required of Technicians in General[1]

Technicians must have the following special abilities:

(1) Proficiency in the use of the disciplined and objective scientific method in practical application of the basic principles, concepts, and laws of physics and chemistry, and/or the biological sciences as they comprise the scientific base for the individual's field of technology.

(2) Facility with mathematics: Ability to use algebra and trigonometry as tools in the development, definition, or quantification of scientific phenomena or principles; and, when needed, an understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.

(3) A thorough understanding and facility in use of the materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used in the technology.

(4) An extensive knowledge of a field of specialization with an understanding of the application of the underlying physical or biological sciences as they relate to the engineering, health, agricultural, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish effective rapport with the scientists, doctors, manager, researchers, or engineers with whom he works and to enable him to perform a variety of detailed scientific or technical work as outlined by general procedures or instructions; but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data.

(5) Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas with complete objectivity orally, graphically, and in writing.

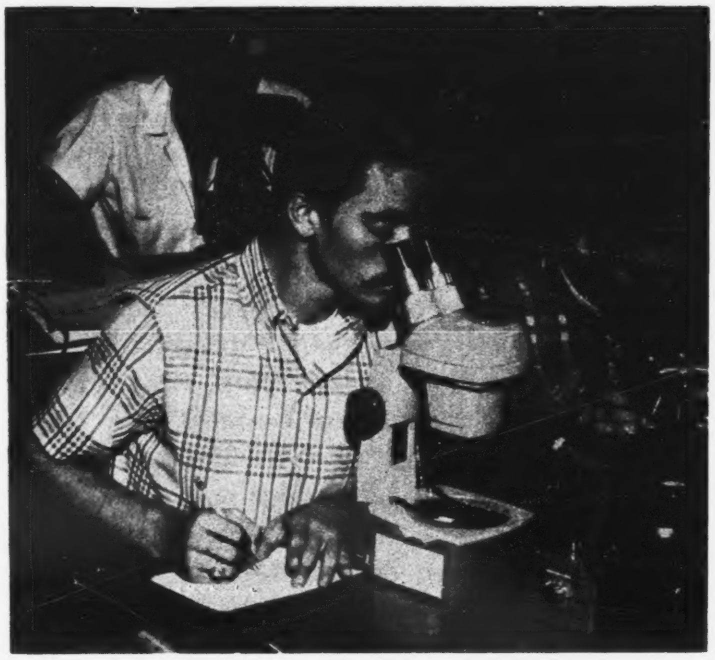

Figure 10.—Programs to educate farm crop production technicians require well equipped laboratories in which to teach special techniques and use of modern scientific equipment used in the technology.

Activities Performed by Technicians in Farm Crop Technology[2]

(1) Applies knowledge of science and mathematics extensively in rendering direct technical assistance to agricultural scientists engaged in scientific research or experimentation. He may help conduct field studies in developing new crop or fruit varieties, mechanized equipment, or uses for agricultural chemicals.

(2) Designs, develops, or plans modifications of new products, procedures, techniques, processes, or applications on his own or under the supervision of an agricultural scientist in applied research, design, and development.

(3) Plans, supervises, or assists in installation or assembling complex apparatus

---

[1] Adapted from U.S. Department of Health, Education, and Welfare, Office of Education. *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs.* OE—80015 Washington: U.S. Government Printing Office, 1962, p. 5.

[2] Ibid., pp 6–8.

or equipment and control systems used in agricultural industry or on the farm.

(4) Advises or supervises the purchase, operation, maintenance, and repair of complex apparatus or farm equipment to obtain maximum operating efficiency.

(5) Plans production or operations as a member of the management unit or as the person responsible for efficient use of manpower, materials, money, and machines used in agricultural production or processing.

(6) Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical apparatus, equipment, services, or product. Or he may need to advise, plan, or estimate costs on production budgets and cropping plans using statistical data.

(7) Performs determinations, analyses and/or tests on agricultural products on the farm or in the laboratory. He may prepare appropriate technical reports covering the tests or make management decisions as a result of them.

(8) Prepares or interprets drawings or sketches of buildings, equipment, or cropping plans and writes detailed specifications or instructions to accompany them.

(9) Reads, selects, compiles, and uses technical information from references such as farm chemical manuals, agricultural codes, operation manuals handbooks, and scientific journals.

(10) Analyzes and interprets information on maturity and grade standards obtained from tests on agricultural products using precision measuring and recording instruments.

(11) Analyzes and diagnoses technical problems that involve independent decisions. His judgment may require technical ability and practical experience to arrive at decisions.

(12) Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. He must know how to go about solving a new problem, including sources of pertinent information. This versatility is a characteristic that relates to breadth of applied scientific and technical understanding—the antithesis of narrow specialization.

A 2-year program must concentrate on primary or fundamental needs if it is to prepare individuals for responsible technical positions in or related to modern farm production. It must be realistic and pragmatic in its approach. *The program suggested in this guide has been designed to provide maximum technical instruction in the time that is scheduled.*

To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it), the technical program often appears to be inordinately rigid and restrictive. While modifications may be necessary in individual institutions to meet regional or local needs, the basic structure, content, level, and rigor of this program should be maintained.

The specialized technical courses in agricultural production are laboratory oriented. They provide application of the scientific principles concurrently being learned in the courses in mathematics, chemistry, and crop botany. *For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program.* This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms. General education courses constitute a relatively small part of the total program. It has been found that students who enter a technical program do so because of the depth in the field of specialization that the program provides.

Faculty

The effectiveness of a program of this type depends largely upon the competence and enthusiasm of the teaching staff. It is important, therefore, that the administrator responsible for faculty selection be aware of the specialized competencies that are required of the teacher due to the nature of the curriculum.

The technical teacher needs more technical knowledge than the high school teacher, but is usually less specialized than instructors of graduate courses at the university. He must be teaching oriented in contrast to research oriented in his work. He should be a master of the skills in his specialty, have a practical knowledge, and yet have the academic background to understand and interpret related technical knowledge. To be successful, he must also understand the special education philosophy for technical education.

Instructors who teach this technical curriculum may be one of two types. The first is the full-time professional teacher. He is professionally prepared, including at least a minimum of teacher education courses at the university level, and devotes full time to the technical program. In selecting this kind of teacher, the administrator should look for former students who have completed a university program, former vocational agriculture teachers who have had work experience and have strengthened this technical preparation, or teachers who have interned in technical programs. Teachers from these sources who have the technical and professional ability are more likely to know and understand the philosophy of technical education.

The other type of teacher may be a part-time teacher from an agricultural industry closely related to the technical program. Part-time teachers from industry may be employed to teach courses requiring special skills or knowledge. They may be prospective employers of the students or former students working in industry. Sometimes it is possible to obtain people who have had teaching experience prior to going into industry.

Both types of instructors may be used to make up the staff. Those from industry may bring needed technical knowledge not possessed by the others. The full-time teachers may be better able to know and counsel the students and to help with teaching methods and classroom management. Full-time instructional staff should comprise the large majority of the faculty for this program.

In all technical programs there should be a team approach to teaching, with close liaison maintained between the various staff members. Coordination of classes should be discussed at staff meetings. Concepts taught in basic science classes should be reinforced in other classes by practical examples and application. This close liaison should also be maintained with the teachers of general education subjects. Student weaknesses in communications should be as much the concern of the technical teachers as it is of the language teacher.

Another member of the team should be the librarian. The librarian responsible for technical education should be included in staff meetings and curriculum discussions whenever possible. This important two-way communication will apprise the librarian of what materials are needed, and the teachers of what new materials are available.

The philosphy of the team approach is to emphasize the integrity of the program. The aims and objectives are: immediate employment, advancement on the job, social competency, and citizenship. They can best be accomplished by an educational program that combines technical knowledge, skills, and general education in a meaningful program.

Faculty members should be encouraged to develop technically and professionally. This can be accomplished by offering released time and financial assistance for inservice training. The inservice training program should be developed to strengthen individual weaknesses. One teacher may profit more from summer employment in industry, while another should attend formal classes.

Inservice teacher training is very important in schools which are changing from vocational programs to technical programs while using the same staff. It is also necessary in schools where university staffs who are accustomed to teaching in the 4-year program teach part time or full time in a technical program. In each case, the aims and objectives, subject matter presentation, and philosophy are different. The administrator should be certain that staff is oriented to these important differences and that individual staff members are allowed time to prepare for the new teaching role.

All technical teachers should be encouraged to maintain close liaison with professional and technical societies related to their teaching speciality. Attendance at society or organization meetings provides opportunities for the teacher to keep abreast of new developments. This is important also for placing graduates in suitable employment.

The workload of the technical teacher should preferably be less than 15 and not more than 20 hours per week. Due to the mixed lecture and laboratory schedule, it is sometimes difficult to compare this teaching load with that of nontechnical teachers in the same school. A comparison is sometimes made by counting lecture hours as one teaching unit and a 3-hour laboratory period as two teaching units. However, these comparisons are difficult to make. The time required to *adequately* prepare for a laboratory period and do the required followup work, may exceed that needed for a lecture hour.

The size of lecture classes will vary with the subject matter being taught. In classes where demonstrations or specimens are used, the size of class should be limited to the number that can readily observe what is being shown. Laboratory classes should be limited to 20 to 24 students. This allows students to see the laboratory materials and for the teacher to give more individual instruction. In some classes it may be possible to have 40 to 50 students in the lecture, and then to divide the laboratory into two sections of 20 to 25 each or three sections of 15 to 18 each.

Good laboratory classes require much time in the preparation of materials and equipment. Whenever possible, it is desirable to use laboratory assistants to help the instructor with laboratory preparation and procedure.

The curriculum outlined in this guide will require a minimum staff of four agriculture instructors, including the department head teaching at least part time, if only a single option is offered. If both options are offered, then a minimum of five agriculture instructors will be required.

A staff of this size provides instructors with the required specialization in the technical subject and permits instructors and the department head to spend some time in job placement.

In addition, those planning the program must provide the required instructional staff for the mathematics, science, communications (language skills), and social sciences.

When admitting classes into the program, it is desirable to plan in multiples of 18 to 24 students. This allows for laboratory sections which will consist of 18 to 24 students and lecture classes of 36 to 48 students.

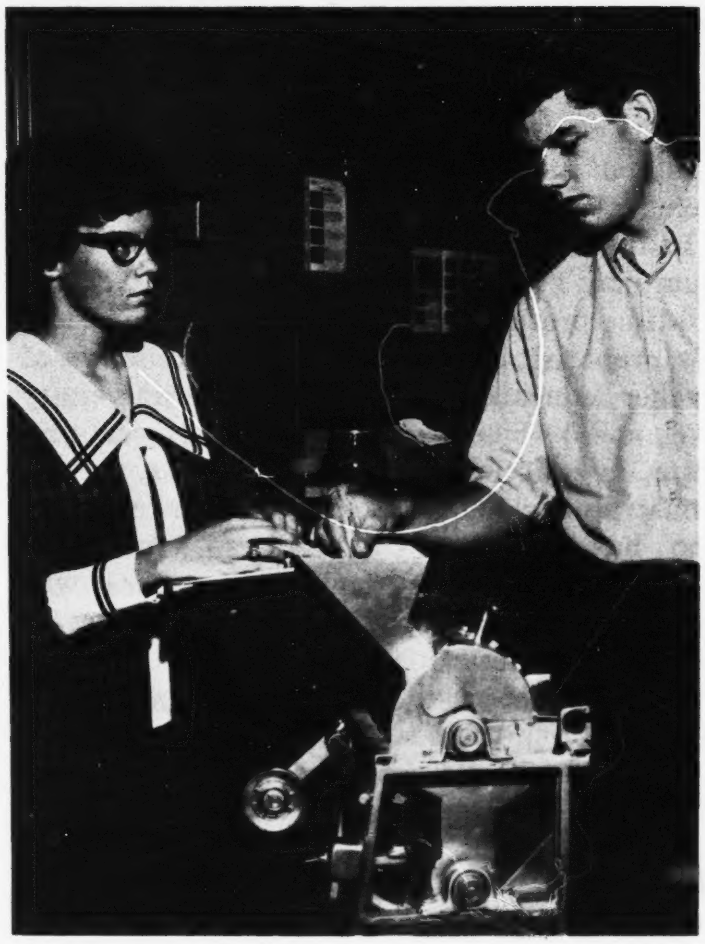

Figure 11.—This laboratory scale grain threshing unit makes it possible for students to analyze threshing operations outside of the normal harvesting season and without full-scale field equipment. Principles of threshing, grain separation, impurity elimination, and avoiding grain damage can be demonstrated.

Student Selection and Services

In order to produce high quality graduates, it is important to have some standards for student selection. Many post high school institutions have an open door policy, wherein all high school graduates are eligible for admission to the school. The open-door policy has merit in that any high school graduate is given the opportunity to enter post high school education. However, the open-door policy should not be interpreted to mean that all who enter the institution can expect to succeed in a rigorous technical program. The importance of some system of selection of students who have a reasonable expectation of succeeding in the program cannot be overemphasized. Schools which are changing from vocational to technical programs must have new curriculums which exhibit the rigor of the technical level. New schools offering a technical program must select students who can master a high level of technical instruction from the beginning.

In cases where unqualified students are allowed to enroll, the students will usually fail or the level of instruction may be lowered. If the level of instruction is lowered, high-quality technicians with the depth and breadth of preparation required for employment are not available. In either case, students or employers soon become disillusioned and the whole program will fail.

Another reason for setting selection standards for students is that it adds strength and potential quality to the program. Students and their parents find the technician objective attractive when they appreciate that it is a special objective which requires high scholastic standards. As it has been pointed out in the section on Special Abilities and Activities of Technicians, the technician does need special skills and abilities that challenge the best efforts as well as the deepest interest of many students. The fact that student selection does take place and that students must do good work to enter and to remain in the program is an important feature in representing the program to student, parents, and prospective employers.

For these reasons, a good counseling and guidance program is necessary. This should start before the student enrolls, preferably at the high school level. Brochures or catalogs which show the program and the pretechnical training required should be distributed to high school counselors. They should also be made available to counselors who may be advising older students or adults.

This program is designed for students with particular interests and abilities in plant and soil science. In addition, they will need to understand basic economics and to have certain mechanical abilities. The recruitment and admissions program should be designed to select students with these interests and abilities.

The program should be open to students who have not had vocational agriculture courses in high school. The entering student should have completed 2 years of high school mathematics, including 1 year of algebra and 1 year of geometry; 1 year of biology, and 1 year of chemistry including laboratory experience, or their equivalent. For those students who have not completed the equivalent of these courses, many post high school institutions offering technical programs offer a pretechnical program.[3] The pretechnical program, which includes up to a year's work, gives promising but unprepared students an opportunity to prepare and to prove that they are ready for a technical program.

Most post high school institutions administer some type of achievement tests to all incoming students. Tests can be used as an indication of verbal and mathematical ability, and to some degree, mechanical ability; but should not be used as major criteria for student selection. Many of the most promising students may not have developed the abstract tools of language, numbers and science required to do well in tests, but can use the tools as needed to serve their vocational interests.

The school admissions officer should have at his disposal the high school transcript showing subjects taken and grades received, various test scores, and grades in pretechnical courses, if taken. In addition, it is recommended that a personal interview be held with each applicant. Such an interview can be of value to determine seriousness of purpose and motivation. Motivation is difficult to measure, but is necessary for success in the program.

For a student out of high school for a period of time working, it is desirable to get a letter of recommendation from his employer. Such a letter will aid in evaluating the student's maturity, seriousness of purpose, and work habits. Qualified women applicants should be fully advised about the career potential of the technology and encouraged if they desire strongly to enter the program.

A student-counseling problem which may be encountered is the student who is still undecided. The uncommitted student should be advised to enter the pretechnical program and to take some of the beginning technical specialty courses to help him determine whether he wants to pursue the technical program.

---

[3] U.S. Department of Health, Education, and Welfare, Office of Education. *Pretechnical Post High School Programs, A Suggested Guide*, OE—80049. Washington: U.S. Government Printing Office, 1967.

Effective guidance and counseling is essential. In addition to each student having a regular counselor, it is desirable to have a member of the agricultural faculty available for guidance as an adviser. Students often develop a close relationship with the agricultural faculty advisor and he can help the student with many of his problems. The faculty adviser can be of special value during times of personal or academic problems or during registration time.

Some type of orientation program for new students is desirable. This can be done before school starts or at the beginning of the term. The orientation program should include campus tours to acquaint students with the campus plus talks by administrators and student personnel representatives regarding campus rules and regulations. A library orientation to acquaint students with the use of library facilities is a very important part of the orientation program.

Placement and followup are also a vital part of the counseling program. Placement of graduates gives meaning to the whole program. A good record of placement helps motivate current students and helps attract new students.

It is desirable that students be placed in summer employment between the first and second year of the program. The jobs should fit the occupational objective of the student to allow him to have real work experience before graduation. The placement of students in suitable and attractive employment upon graduation is probably the most important part of the program.

Job placement can be managed in various ways. Experience has shown that individual instructors can do much of the placement work. During visits to farms, agricultural industries, or advisory committee meetings, the member of the instructional staff should always keep placement in mind and be prepared to make recommendations when employers ask for help.

Periodic followup studies of previous graduates should be made. This can be done by questionnaires through the mail or by personal visits to places of employment. A check on the progress of graduates offers a good means of curriculum evaluation and can be used as a basis for improvement of the program.

Another part of the student service program is the sponsoring of a departmental student organization. Student club activities offer a good media to utilize important speakers, to show good films of general interest and to teach group dynamics and parliamentary procedure. Student organizations can be helpful in sponsoring field days or open house for guests from local high schools or agricultural industry. Student club organizations have been found to be important as a medium for the development of leadership qualities in students.

Each student should be given the opportunity to become acquainted with members of technical societies or farm groups in his area of specialization. Many technical societies offer student membership rates. Contacts with these groups help the student become acquainted with people active in the field and with trade publications. Such contacts may eventually help the student in finding employment, and they provide a future source of technical information.

Some type of degree or certificate should be conferred by the institution to indicate the student's successful completion of the program. These may be presented at graduation or some similar ceremony held to recognize achievement. Outstanding individual achievement also may be recognized at this time or at a banquet or meeting of the student organization.

Textbooks, References, Visual Aids

Textbooks, references, and visual aids must be reviewed constantly in light of new developments in science, agriculture, and teaching methods. The impact of developments in science applied to agriculture is demanding fresh textbooks, articles in journals, and teaching materials.

Departures from teaching the traditional college course in various subjects also are creating a need for new and different books and references. In many courses, it will be necessary for the teacher to develop his own teaching materials. It also may be necessary for students to read from many different sources in the library rather than to have one assigned text.

Students should be encouraged to use the library to look up materials and to become acquainted with sources of information. In a changing technology, knowing how to find information is as important as knowing facts. Class assignments in the library are necessary to familiarize the student with its use. Technicians should be encouraged to use the library so that it becomes an important tool in the learning process. The growth and success of the graduate technician will depend in large measure on his ability to keep abreast of changes in his field. Libraries are information sources with trained personnel who classify source data and assist those seeking it to find pertinent information quickly.

The teacher should familiarize himself with the available books before selecting that best suited to the particular needs of the students as a text.

Visual aids may be a great help to the teacher when they are pertinent to his teaching objective. Only a few have been listed in this guide because of changing techniques and procedures which tend to make films obsolete in a relatively short time. The teachers should preview any visual aids before use in order to determine whether they will fit into the teaching situation. At times only part of a film might be used to demonstrate a point. If so, the film should be set up in the projector before class to eliminate waste of time.

New types of visual aids are being developed and should be considered whenever possible. In some new schools the buildings are being planned for educational television. Video tapes of demonstrations or procedures can be produced now for about $1 per minute or approximately $50 for a class period. Video tapes can be used in the library for individual study by students.

Administrators and teachers should check with the local telephone company in regard to amplified phone conversations in classrooms. In courses such as agricultural economics or farm management, it is possible to have prearranged phone conversations with experts in any part of the country for a relatively small charge.

Many new audiovisual devices are available now, and new ones, including teaching machines, are gaining more general acceptance. All such teaching aids should be thoroughly studied by teachers and administrators before investing money and time in them. Staff members need to be adequately prepared in the use of equipment or materials before effective presentation can be made to the students. The unit cost in relation to educational effectiveness should be a prime consideration before purchase.

Library

A central library under the direction of a professional librarian is important to the success of the teaching of technology curriculums. Most instructors have private libraries in their offices from which they may select books of special interest in their personal conferences with students and thereby stimulate interest in related literature. However, a central library, headed by a professional librarian, insures the acquisition and cataloging of the library content according to an accepted library practice and provides the mechanics for location of reference materials by the use of systematic card files. It also provides the mechanics for lending books to students in a controlled and orderly manner typical of libraries which they might encounter after leaving school.

Study space with suitable lighting and freedom from outside distraction should be provided in the library for short-term study of reference data, and provisions for checking out of reference materials for out-of-library use should be systematic and efficient.

The content of a library must adequately provide the literature containing the knowledge encompassed by all subjects in a curriculum and extending somewhat beyond the degree of complexity or depth encountered in classroom activities. Literature dealing with highly specialized aspects of subject may be acquired as needed or may be borrowed by the librarian from more comprehensive libraries.

The teaching staff and the library staff should actively cooperate with one another. The teaching staff must cooperate with the library staff on materials to be acquired and should be responsible for the final selection of materials that support their technical courses. It must take the initiative in recommending new library content to keep it current, pertinent, and useful. In addition to reference books on all important aspects of crop, fruit, and vine production, the library should contain current magazines pertaining to crops, soils, and farm management, bulletins and information from the local extension service, and a wealth of trade and commercial literature.

The library staff should periodically supply the teaching staff with a list of recent acquisitions complete with call numbers. Technical, trade, and association journals should either be circulated to the teaching staff or be placed in a staff reserve area for a short time before they are made available for general library use.

In addition to reference materials, journals, and trade publications, a library should have material of an encyclopedic nature available for quick reference, and should maintain reference index material.

Visual aid matters may be centered in the library. Visual aids should be reviewed and evaluated by both the librarian and a member of the teaching staff as they become available. This procedure will insure that appropriate visual aids are acquired by the library and should familiarize members of the teaching staff with exactly what is available and where these aids may best be used in the technical programs. Visual aids should always be previewed and analyzed for timeliness and pertinency before being used in a teaching situation.

More and more libraries are becoming comprehensive learning centers with individual student carrels multimedia learning materials, and programed learning materials for a variety of subjects.

Each instructor should be encouraged to build up a collection of colored slides illustrating farming practices in other areas and farming operations at different seasons when the actual operation cannot be observed. These may be kept in the library.

A well-equipped, modern library should have some type of duplicating service available so that copies of library materials may be obtained easily by students and staff. This service allows both students and staff to build up-to-date files of current articles appropriate to the courses in a curriculum. This service should be available to the students at minimum cost and, within reasonable limits, free of personal cost to the staff.

A list of suggested texts and references may be found at the end of each course outline. In order to have a current list, few books over 10 years old have been included. In cases where books over 10 years old are still considered current, a notation to that effect has been made. It should be possible to select suitable texts or references from the lists presented. However, it should not be assumed that unlisted books are not suitable. There are, no doubt, others which are excellent.

One source of references which has been purposely omitted is the university and experiment station circulars and bulletins. These are published on a wide variety of subjects, too numerous to include in this guide. In addition, materials published in each state are usually best suited to the state where they are published and may not be of general interest in other parts of the country. The teacher should contact the university publications office in his State for a list of available publications.

Laboratory Equipment and Facilities

A well-equipped laboratory is necessary to provide for valid laboratory experience, basic in nature, broad in variety, and intensive in practical experience. The technician program should include equipment that illustrates principles used in grading, testing, processing, weighing, and measuring agricultural products, soils, or equipment.

Variety and quality of equipment are more important than quantity. Each piece of laboratory equipment should be considered carefully before purchase. A study of types of equipment used on farms and in laboratories in the local area should be made. The ways in which this equipment might be used in laboratory experiences should be considered. Study may show that laboratory models of certain large expensive machines can be purchased and used to illustrate principles.

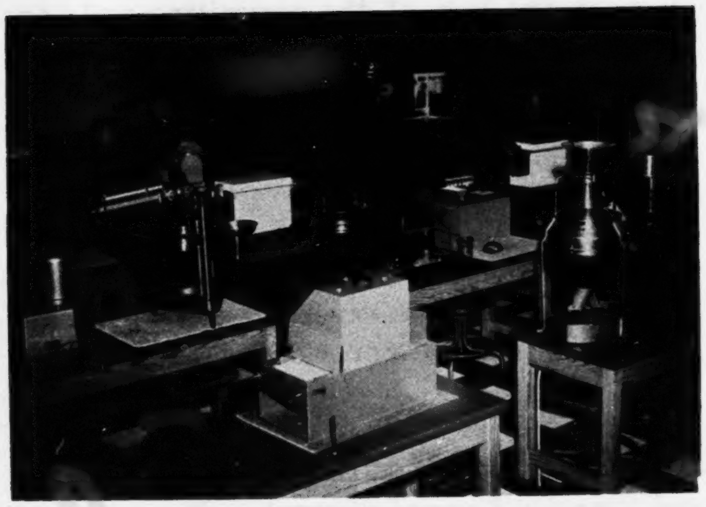

Figure 12.—Judicious selection of testing equipment for agricultural products makes it possible to teach various principles of farm crop production in the laboratory.

The laboratory equipment recommended in this guide has been carefully considered. Its main use is to teach students the various principles of testing or grading agricultural products. In addition, some of the equipment is excellent for teaching critical thinking and proper laboratory procedures. The economic importance to the farmer of testing is stressed as the equipment is used.

The equipment has been selected to illustrate principles or concepts. Even though the machines will change, if the student learns the principles and concepts of a testing procedure he can adapt to new or improved machines.

A list of the various kinds of equipment needed to teach this curriculum is included in a later section. It may seem rather extensive, but it is considered vital to the program, and the curriculum should not be attempted without it.

In addition to the equipment for the laboratories, it will be necessary to have greenhouses and a plot of ground for a school farm laboratory. In established schools where ornamental horticulture is also being taught, the greenhouses can be used in conjunction with that program. However, the greenhouses are used for soils, botany, plant propagation, weeds and weed control, seed production, and the other plant production classes. For this reason, adequate space under glass should be considered. This is even more important for schools located in regions with a cold climate making outside work difficult.

The size of the plot of ground for a school farm laboratory will vary with the size of the program. In schools which offer other technical programs, the plots must be larger. For crops and fruit and vine production, adequate acreage should be obtained for test plots of grains and forages, row crops, and a fruit orchard. Careful consideration should also be given to irrigation facilities for at least part of the plot.

The school farm laboratory can be used as demonstration plots for various agricultural chemicals, irrigation methods, and equipment-use when it is difficult to use local farms for such purposes. In addition, many of the plant specimens for use in the laboratory can be grown in the greenhouse or on the school farm. The farm plot ideally should be located near the school. If possible it should be owned by the institution; if not owned, it should be available under a *long-term* leasing arrangement. (See further discussion under land requirements.)

gure 13.—In equipping farm-crop production laboratories, sufficient high quality equipment must be available to permit each student to use the equipment. Here a student is performing a test to determine the sedimentation qualities of wheat, an important test to determine the baking quality of the wheat.

Advisory Committees and Services

The success of technician education programs depends to a great extent on the formal and informal support of advisory committees.

When an institution decides to consider the advisability of initiating a particular technological program, the chief administrator or dean should appoint the advisory committee.

The special advisory committee for the farm crop production technology program should be comprised of representatives of employers and public employment services, scientific or technical societies and associations in the field, and knowledgeable civic leaders who meet with and advise the specialists on the school's staff. Such members serve without pay as interested citizens. They have no legal status but provide invaluable assistance. The committee normally consists of about 12 members (but may vary from six to 20), who generally serve for a 1- to 2-year period. The head of the institution or the department head of the technology is ordinarily chairman. It should be remembered that such people are always busy; therefore, meetings should be called only when committee action can best handle a specific task or problem.

The committee assists in surveying and defining the need for the technicians: the knowledge and skills they will require; employment opportunities; available student population; curriculum, faculty, laboratory facilities and equipment; cost and financing of the program. When the studies indicate that a program should be initiated, the committee's help in planning and implementing it is invaluable.

Frequently the committee gives substantial help to school administrators in obtaining local funds and securing State and Federal support for the program. When the students or graduates seek summer or permanent employment, the committee aids in placing them and in evaluating their performance. These evaluations often will result in minor modifications, which more closely relate the program to employment requirements.

The advisory committee can use this guide, designed primarily for planning and development of full-time preparatory programs in post high school institutions, as a starting point, modifying it to meet local needs. The program can also form the basis for courses to meet the requirements of employed adults who wish to upgrade or update their skills and technical capabilities. In this way the school administration, with the help of the committee and special consultants, can effectively initiate the needed program, quickly develop it to a high level of excellence, and maintain its timeliness.

It is strongly recommended that an advisory committee be provided for this technology. Members can be appointed for regular terms, subject to reappointment, and membership should rotate so some experienced advisors are present with some new ones each term.

Scientific and Technical Societies and Trade Associations

Scientific and technical societies[4] and trade associations are an important source for faculty members of instructional materials and other benefits for themselves and students. Such societies provide, through their publications and meetings, immediate reports and continuing discussion of new concepts, processes, techniques, and equipment in the physical sciences and related technologies. Their presentation of scientific and technical discoveries and their interpretation of them explain the relationship of the theoretical scientist's work to the applied science practitioner's requirements. They are an invaluable aid in keeping abreast of new developments in a particular phase of science.

Less conspicuous but extremely important is the support which societies may give (1) in helping to develop evidence of need for a training program; (2) in helping to promote the program; (3) in enlisting members' support for the program; (4) in helping to provide work experience for students; and (5) in helping with the placement of graduates.

Associations and societies may supply resource people to speak to classes. They also may serve as hosts to student groups on field trips to study specific phases of the industry.

Instructors should be encouraged to become active members in these societies so that they may learn quickly of new technological developments. Membership will also enable them to meet people in the community who are most actively interested in the field. Some educational institutions pay all, or part, of the costs of membership dues and attendance at local or national meetings in order to encourage staff participation in selected societies.

---

[4] U.S. Department of Health, Education, and Welfare, Office of Education. *Scientific and Technical Societies Pertinent to the Education of Technicians.* OE—80027. Washington: U.S. Government Printing Office, 1965.

Early in their studies students should be required to become acquainted with the literature and services of scientific, technical, and engineering societies. They should also be encouraged to join those which offer students affiliate memberships.

The following is a selected listing of some of the organizations and associations which are pertinent and relate to crop, fruit and vine production. Additional data, including the address, purpose, and publication, if any, of each association, are listed in the appendix.

Agricultural Aircraft
Agricultural Research Institute
American Entomological Society
American Farm Research Association
American Horticultural Society
American Mushroom Institute
American Pomological Society
American Potash Institute
American Rice Growers Cooperative Association
American Society for Horticultural Science
American Society of Agronomy
American Society of Enologists
American Soybean Association
American Sugar Cane League of the U.S.A.
Association of Official Seed Analysts
Beet Sugar Development Foundation
Calavo Growers of California (Avocado)
California Almond Growers' Exchange
California Date Growers' Association
California Fig Institute
California Fruit Exchange
California Grape and Tree Fruit League
California Raisin Advisory Board
California Strawberry Advisory Board
Cherry Growers' and Industries' Foundation
Council for Agricultural and Chemurgic Research
Cranberry Institute
Crop Protection Institute
Crop Quality Council
Crop Science Society of America
Date Administrative Committee
Date Growers' Institute
Diamond Walnut Growers
Entomological Society of America
Farm Equipment Institute
Farm Equipment Manufacturers Association
Farm Film Foundation (Motion Picture)
Federated Pecan Growers' Associations of the United States
Florida Citrus Mutual
Florida Fresh Citrus Shippers Association
Florida Lychee Growers' Association
Florida Mango Forum
Hawaiian Sugar Planters' Association
International Cotton Advisory Committee
International Crop Improvement Association (Seed)
International Plant Propagators' Society
Lemon Administrative Committee
National Agricultural Chemicals Association
National Association of Greenhouse Vegetable Growers
National Association of Produce Market Managers
National Association of Wheat Growers
National Container Committee
National Council of Commercial Plant Breeders
National Fertilizer Solutions Association
National Junior Vegetable Growers' Association
National Plant Food Institute (Fertilizers)
National Soybean Crop Improvement Council
North American Blueberry Council
Northern Nut Growers' Association
Pan American Tung Research and Development League
Potato Association of America
Produce Packaging Association
Research and Development Associates, Food and Container Institute
Seed Pea Group
Soil Conservation Society of America
Soil Science Society of America
Sugar Research Foundation
Sunkist Growers (Fruit)
Tobacco Institute
United Fresh Fruit and Vegetable Association
U.S. National Committee, International Commission on Irrigation and Drainage
Vegetable Growers' Association of America
Weed Society of America
Western Agricultural Chemicals Association
Western Growers' Association (Vegetables)

THE CURRICULUM

Functional competence in a field as broad as farm crop production or fruit and vine production has at least three components around which a curriculum must be designed:

(1) Training should prepare the graduate to be a productive employee in a job at the entry level.

(2) The broad technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility.

(3) The foundations provided by the training must be broad enough that the graduate can do further study within his field. This further study may be the reading of journals, new text materials, or formal course work.

The curriculum shown here is designed to meet the three requirements. No curriculum can be considered terminal in the sense that the student stops learning. The curriculum is designed to help the student acquire as many of the special abilities needed for entry level as well as to provide the tools needed for further study.

This curriculum is intended as a guide for program planning and development primarily in post high school institutions. Adaptations can be made to suit various situations in several kinds of schools. The level of instruction represents a consensus on the level of proficiency required for success in occupations in which manpower is in short supply today and threatens to be even more so in the future. The curriculum is a product of the efforts of many people—educators, scientists, farm operators and other employers, and the staff of the U.S. Office of Education.

The curriculum is organized as 17-week college semesters rather than as college quarters because it is usually easier to convert a program from semesters to quarters.

Each semester is considered to be 17 weeks in length. The curriculum and course outlines show a 16-week semester schedule. It will be noted that no examinations are scheduled in the course outlines which follow later. It is intended that part of the additional week be used for examinations.

Outside study is a significant part of the students' total program. In this curriculum 2 hours of outside study time have been suggested for each hour of scheduled class time. A typical weekly work schedule for a student in the first semester of this curriculum would be: Class attendance, 13 hours; laboratory, 15 hours; outside study, 26 hours—making a total of 54 hours per week. This is a full schedule, but not excessive for this type of program. The student will benefit from a careful budgeting of time.

The Curriculum Outline for Field and Forage Crop Production Option

First Semester

Courses	Class hours	Laboratory hours	Outside study	Total hours
Mathematics I	3	0	6	9
Crop Botany	2	3	4	9
Agricultural Chemistry	2	6	4	12
Communications Skills	4	3	8	15
Field Crops	2	3	4	9
Total	13	15	26	54

Second Semester

Courses	Class hours	Laboratory hours	Outside study	Total hours
Mathematics II	3	0	6	9
Agricultural Economics	3	0	6	9
Agricultural Mechanics	2	3	4	9
Soil Science	2	3	4	9
Forage Crops	2	3	4	9
Plant Diseases and Pests	2	3	4	9
Total	14	12	28	54

Summer Occupational Experience

Third Semester

Courses	Class hours	Laboratory hours	Outside study	Total hours
Farm Records and Reports	2	0	4	6
Farm Power	2	3	4	9
Irrigation and Water Management	2	3	4	9
Weeds and Weed Control	2	3	4	9
Cereal Crops	2	3	4	9
Elective [1]	2	3	4	9
Total	12	15	24	51

Fourth Semester

Courses	Class hours	Laboratory hours	Outside study	Total hours
Farm Management	2	3	4	9
Farm Machinery	1	3	2	6
Crop Marketing	3	0	6	9
Seed Production	2	3	4	9
Soil Management	2	3	4	9
Principles of Social Science	3	0	6	9
Total	13	12	26	51

[1] **Electives**
Truck Crops or Grassland Management

The Curriculum Outline for Fruit and Vine Production Option

First Semester

Courses	*Class hours*	*Laboratory hours*	*Outside study*	*Total hours*
Mathematics I	3	0	6	9
Crop Botany	2	3	4	9
Agricultural Chemistry	2	6	4	12
Communications Skills	4	3	8	15
Small Fruit Production	2	3	4	9
Total	13	15	26	54

Second Semester

Mathematics II	3	0	6	9
Agricultural Economics	3	0	6	9
Agricultural Mechanics	2	3	4	9
Soil Science	2	3	4	9
Subtropical Fruit Production	2	3	4	9
Plant Propagation	2	3	4	9
Total	14	12	28	54

Summer Occupational Experience

Third Semester

Plant Diseases and Pests	2	3	4	9
Farm Power	2	3	4	9
Irrigation and Water Management	2	3	4	9
Deciduous Fruit Production	2	3	4	9
Weeds and Weed Control	2	3	4	9
Farm Records and Reports	2	0	4	6
Total	12	15	24	51

Fourth Semester

Farm Management	2	3	4	9
Farm Machinery	1	3	2	6
Crop Marketing	3	0	6	9
Fruit Processing	2	3	4	9
Soil Management	2	3	4	9
Principles of Social Science	3	0	6	9
Total	13	12	26	51

Brief Descriptions of Courses for the Field and Forage Crop Production Option

First Semester

Mathematics I
A course offering a basic mathematical program accenting the fundamental concepts of our number system, involving whole numbers, decimals, and fractions. The course develops the principles of algebra and the use of algebraic formulas. Basic ideas on the use of the slide rule are introduced, especially for the solution of problems involving ratio, proportion, and percentage.

Crop Botany
A course designed to provide the student with a working knowledge of the fundamental structures and processes of plants. Topics included are plant anatomy, physiology, morphology, reproduction, and genetics as they relate to crop production. In the laboratory the student will conduct experiments to better understand basic plant structures and processes.

Agricultural Chemistry
A basic course in the composition of matter and physical and chemical changes; fundamental laws and principles. The properties of the common elements and their compounds, with their application to agriculture, are studied. Laboratory sessions are designed to give practical application of the theory expressed in lectures.

Communication Skills
A course in oral and written communications. The course is designed to promote greater competency in recording, talking, writing, and listening. The laboratory period provides practice in the various skills using teaching machines, programed learning and other instructional aids.

Field Crops
A study of the characteristics of field crops and their response to environmental conditions with emphasis on the problems concerned with their production and marketing. Laboratory periods include work in identification, grading, and evaluation of crop products.

Second Semester

Mathematics II
A course offering a program of algebra, basic logarithms, and numerical trigonometry. Practical problems in agriculture are developed and solved by means of the use of the slide rule and mathematical tables as much as possible. Areas, volumes, ratios, percentages, proportions, and simple compound interest are covered.

Agricultural Economics
A course in the economic development of modern agriculture, including problems of agricultural production and marketing. The changing role of modern agriculture and its social and political implications are emphasized.

Agricultural Mechanics
A course in the basic mechanical concepts used on a modern farm. The use of safety and good work habits are emphasized. Print reading, sketching and drafting, carpentry, working with concrete, plumbing, painting, electrical, welding, and hot and cold metal work are the subjects of study. The laboratory includes practical applications and the development of limited skills associated with the studies, with practice in their use as time allows.

Soil Science
A course in the physical and chemical properties of soils as influenced by climate, the parent material from which they were formed, the topography of the area, organisms in the soil, and time. The laboratory period includes map reading, moisture determinations, chemical analyses and study of approved soil practices in the area.

Forage Crops
A course in the adaptation, utilization and culture of those crops grown for pasture, hay, silage, and soilage. During the laboratory, the student will learn to identify the various species of forage and to evaluate those characteristics associated with their feeding value.

Plant Diseases and Pests
A course of the principles involved in controlling plant diseases and pests; primarily insects. The control of certain rodents and larger animals is included. Laboratory work will in-

clude identification of pests and setting up pest control programs.

Third Semester

Farm Records and Reports
A course to provide the student with an understanding of how to keep and use the records of the farm business. Written reports on various farm operations are required as part of the course work.

Farm Power
An elementary course in the fundamental mechanical principles of engines and their components in order to supply power for the modern farm. The laboratory period includes testing, adjustment, maintenance, and study of engines and power transfer.

Irrigation and Water Management
A course in the principles and practices of irrigation including soil, water, and plant relations; and water sources, quality, methods of distribution, and measurement methods and structures. Irrigation methods and structures, field preparation and water measurement are included in the laboratory work.

Weeds and Weed Control
A study of the identification, growth characteristics, and control of those weeds which are detrimental to cultivated crops and grasslands. During the laboratory period the student will learn to identify the important species of weeds and to make actual applications of herbicides.

Cereal Crops
A comprehensive course in the growth characteristics, cultural practices, and the marketing of cereal crops. Special emphasis is placed on the relationship of cultural practices and environment to market quality. In the laboratory, the student is given an opportunity to gain actual experience in identifying, grading, and determining the market quality of cereals and cereal products. Comprehensive use will be made of quality testing devices and seed handling machines. In addition, provision is made for visits to marketing agencies and processing plants.

Truck Crops
A course designed to provide the student with insight into the specialized problems of truck crop production. The course includes cultural practices, vegetable storage, transportation, and marketing. Laboratory experiences will be provided to demonstrate the practical application of principles emphasized in lecture.

Grassland Management
A study of conditions affecting grasslands and the manipulation of those factors which will enhance soil conservation and livestock grazing capacity. Laboratory periods include identifying the grassland species, charting, mapping, inventorying the range and evaluating vegetation.

Fourth Semester

Farm Management
A course in the selection, organization, and operation of the modern farm. The laboratory period is to provide time for observing and practicing activities associated with operations and management.

Farm Machinery
A course in the selection, operation, servicing, adjustment, and maintenance of machinery and equipment. The laboratory will include calibration, adjustment, and evaluation of performance of tillage, planting, weed control, harvesting, and processing machinery.

Crop Marketing
A course in the principles and practices of marketing crop products emphasizing problems in distribution and normal channels of trade. Marketing problems for specific crops are included.

Seed Production
A course in the reproductive processes, principles of breeding, environmental response, and the harvesting and processing of seed crops. In the laboratory the student will gain actual experience in test plot work, seed processing, and seed testing.

Soil Management
A study of those management practices that are effective in maintaining soils in a highly productive condition. Laboratory assignments will parallel lecture topics including conservation, fertilization, and tillage practices.

Principles of Social Science

A course in the principles of social science as they apply to man and his place in society. Individual and group behavior as they affect human relations will be studied.

Brief Descriptions of courses Unique to the Fruit and Vine Production Option

First Semester

Small Fruit Production

This course is designed to acquaint the student with various phases of producing grapes, bushberries, and strawberries. The course will cover all cultural practices including design of the planting area, establishing young plants, fertilization, irrigation, pest control and harvesting.

Second Semester

Subtropical Fruit Production

A course in the production of subtropical fruits, including avocados, citrus, dates, and olives. A study of fundamental information relating to commercial orchard management of these fruits. Laboratory work parallels lectures with emphasis on various cultural practices.

Plant Propagation

A course designed to acquaint the student with commercial methods followed in the propagation of crop plants and fruits. Reproduction of these plants by seeds, cuttings, grafts, layers, runners, and division are covered. Laboratory sessions are planned to give the student practice in plant propagation.

Third Semester

Deciduous Fruit Production

A study of the principles and practices involved in production of deciduous fruits. Emphasis is given to the selection of the orchard, cultural operations, fruit handling and marketing. Laboratory periods provide time for practice and observation of various cultural and management operations.

Fourth Semester

Fruit Processing

An elementary course in techniques of fruit processing and how these relate to selection of raw material used and the quality of product obtained. Laboratory periods will be devoted to testing and evaluating fresh and processed fruits.

Curriculum Content and Relationships

Curriculum content and organization are influenced by the special occupational needs of the graduates, the limited time available to teach the curriculum, and new methods or techniques which seem imminent in the field of crop, fruit, and vine production. The technician is expected to know how to perform the manual skills required in a job, so that more emphasis is placed on this than might be done in a similar Baccalaureate program. The student is also taught the special mental skills required in an occupation. It is assumed that some transfer of training will take place to prepare the student for new situations as they may arise on the job.

Due to the limited time available, great care has been exercised in selecting and arranging the subject matter in this curriculum. The teaching of concepts is important when time is limited. It is not possible to include all of the chemistry, mathematics, botany, and biology that is found in a 4-year program. The concepts which are most important to agriculture and their application to farm crop production are therefore stressed. The production courses are designed to reinforce the concepts which are learned in chemistry, crop botany, and mathematics. For these reasons, the sequence of courses shown in the curriculum is important.

The relationship between laboratory time and class lecture or theoretical study time is of great importance in a technical education curriculum. Skills, techniques, and applied principles needed by the technician can be taught in the laboratory. Organized and related ideas, concepts, and factual information can be taught in "theory" classes and judiciously illustrated by demonstration and other visual aids, employing selected texts and references, and requiring regular and systematic outside study on the part of the student. Group teaching usually makes more efficient use of the instructor's time in a theory class than in a laboratory. It tends to emphasize and develop the student's skills in obtaining knowledge from printed sources. Thus, there must be a special relationship between the amount of the scientific and technical specialty taught in the theory classes and that taught in the laboratory.

In technical curriculums it is mandatory that specialized technical course work be introduced in the first semester. Deferring this introduction even for one term imposes serious limitations on the effectiveness of the total curriculum. Two of the important advantages that occur from an early introduction of the technical specialty follow:

(1) The student who enrolled in school to study farm crop production technology starts his training immediately in this specialty. If his first semester consists entirely of general subjects—mathematics, English, social studies—he might lose interest.

(2) By introducing the technical specialty in the first semester it is possible to achieve greater depth of understanding in specialized subjects in the later stages of the 2-year program.

Safety and careful workmanship are stressed throughout the course of study. There are potential dangers involved in a technician's work. By learning to use careful procedures in such operations as the use of chemicals and machinery and by observing the normal safety practices, many dangers can be avoided. The importance of protecting human life and limb is paramount, but students also need to learn good work habits and to develop a pride in workmanship. On the job the technician will be working with expensive equipment and delicate plants. A slight mistake in calibrating a spray rig, a fertilizer, or seed drill can result in loss of time, money, or even life. Teaching proper care of expensive equipment is more important than how to repair it as a result of negligence.

Discipline and intellectual honesty are an important part of the training. Students should learn to be accurate in laboratory work and honest in reporting. The instructor's responsibility is to see that each student does his own work and reports it in his notebook. If an experiment does not produce the expected results, the student must try to determine why.

The basic and beginning courses in crop production in either option, the science courses, communications skills and mathematics are included in the first and second semesters. This helps provide an educational balance of courses and helps the student see a relationship between these courses. It also establishes the breadth of base in science and mathematics permitted by the limited time for the curriculum and provides the foundation for study of the specialties in greater depth during the third and fourth semesters.

This curriculum provides a substantial amount of time for laboratory work in the various courses. In the first semester the student is learning laboratory skills in chemistry and crop botany as well as principles he will use in soils, irrigation and soil management. In field crops courses in the first semester he is learning to apply the scientific principles of botany to growing crops. As soon as the underlying theory is developed and understood, it is applied in the laboratory work with each succeeding course adding experience in greater depth.

The courses in farm management, marketing, and seed production have been included in the last semester to tie together and apply the principles and practices taught in the earlier science, production, and agricultural economics courses, and to provide a basis for coping with technical changes in the future.

New and improved methods of farming are being developed to enable farmers to become economically effective on higher priced and/or on submarginal land brought into use by the economic pressure of population growth. New citrus plantings are being tried on drained swamp land in the southeast. Raw desert land requiring reclamation, irrigation, and new varieties of crops is being utilized in the west. In the Midwest, low spots with poor drainage take their toll on crops when rain is excessive or crops dry up when rainfall is short. Herbicides for weeds are not effective unless moisture can be controlled. All of these require technical know-how.

For these reasons, courses such as irrigation and water management, weeds and weed control, and soil management have been included. These topics are found in very few curriculums at the present time, yet appear to be needed in all agricultural areas.

Employers want technicians who can do not only their daily tasks but who are able to communicate in writing and speaking, to figure, and to get along with other people. General education courses in this curriculum are designed to accomplish this objective.

The communication skills course is provided in the first semester to facilitate the student's use of language throughout the entire program. It includes both writing and speaking. In addition, instructors in other classes should assign papers or reports and insist upon proper usage of English including spelling, grammar, and sentence structure. Additional training in speaking can be given by means of oral reports in classes or through the work of the departmental club.

Principles of economics, including our American economic system, are taught in agricultural economics, farm management, and the various marketing courses.

The Social science course is designed to help the student see himself as a member of society and to see how his society functions. Relationships with other people are stressed in the course, both from the standpoint of the worker and the employer. The content of the social science course is related to the work the student has had in economics, marketing, and farm management. The general education requirements vary considerably from state to state. For that reason the general education content of this curriculum has been designed to meet the minimum needs of the students taking it.

Summer working experience in some type of crop production is recommended between the first and second years of study. This should be a mandatory requirement, especially for students without previous farm work experience. The principle objective of the work period is to familiarize the student with some of the many aspects of farm crop production. Practical application of the many principles discussed permits the student to obtain a greater realization and appreciation of the technical requirements of farming.

When this working experience can be arranged, the student should receive the prevailing wage. It is desirable that his time be spent in one operation so those in charge may come to know his qualifications and character. A student should make his own arrangements for employment providing they meet the approval of the farm crop production technology staff. Or, he can be assigned a position by the staff. Exceptional cases that might justify waiver of this requirement should be approved by the farm crop production technology staff.

Since the work period is designed to meet an educational objective, it is desirable to have the employer make any special arrangements possible to provide the student with a greater understanding of the operations performed and of the necessary technological aspects of work. A planned and arranged system of job rotation experiences is a helpful training procedure.

Some institutions may organize employment experience as a part of a cooperative work-study plan.

Cooperative Education Plan

This technology is adaptable to a cooperative arrangement: a plan which offers important advantages to students, the school and to employers of technicians. A cooperative education program is a plan for student learning through coordinated study and employment experience. Students alternate periods of attendance at the institution with periods of employment in business or industry. The employment constitutes an essential element in the educational process. The student's employment should be related as closely as possible to some phase of the field of study in which he is engaged.

When a student tests his academic theory in a work situation, study becomes more meaningful. The co-op student learns not only the applied essentials of his technology, but also the importance of reliability, cooperation, and judgment as an employed worker in his chosen field.

The co-op student's career choice is stimulated and shaped by his work experiences. Should he find satisfaction in his work, he returns to the classroom stimulated to learn as much as possible about his future career. Should he find through his work experience that he is not fitted to a specific area of work, he may decide to change his major field of study when he returns to the college. This decision may prevent him from wasting his time and money on a misguided choice of study.

A class of students in cooperative technical programs usually spends the first semester or the first two quarters in school; then the class is divided so that half have a semester or quarter-semester of employment experience while the other half continues to study. During the next semester or quarter the half which worked returns to its formal studies at school while the other half of the class is employed. Students usually alternate again so each student has two semesters or at least two quarters of work experience in his program. The student's technical program is lengthened beyond the curriculum outlined in this document by an amount of time equal to the total length of the employment experience.

Specific employment is obtained, as circumstances permit, by the educational institution with the cooperation of the student. The institution regards the work-experience program as an integral part of the technician educating program as a whole. It is not to be regarded primarily as an earning opportunity although all students while working are paid at the prevailing wage scale for the job they hold. Work reports by both the student and the employer are submitted to the school work program coordinator.

The cooperative work-experience program is an opportunity to gain directly related experience which makes the student more desirable as an employee. Many students, as a result of their work-experience with a particular establishment, have been offered permanent positions with that organization upon completion of their schooling. Cooperating establishments agree, however, not to make offers of employment which become effective before the completion of the technician educating program.

Cooperative programs provide special opportunities for the educational institution to maintain close contact with employers in their various programs. This contact becomes a valuable two-way channel of communication which helps the educational institution to keep its knowledge of specific employer needs in each technical field up-to-date and at the same time keeps employers acquainted with and involved in the program of the institution.

Suggested Continuing Study

It has been pointed out that this curriculum is not intended to make the individual proficient in all duties he may be asked to perform. Proficiency comes only with experience, practice, and further study of specialized problems that may arise on the job. It is also impossible to predict changes that may arise due to our changing economy and technology. Some form of continuation of study for graduates of technology programs is therefore mandatory.

By reading current literature related to the technology, the student can keep abreast of technical developments of his special field, but this tends only to build on the organized technological base provided by the curriculum he studied.

Continuation of the educational process provides the most efficient and practical means for the graduate technician to add important related areas of knowledge and skill to his initial education. Supplementary courses have the advantages of systematic organization of subject matter, disciplined and competent teaching, class discussion, and scheduling on evening or Saturday hours outside of the graduate student's working day.

If the majority of the graduates return to farming, then it is recommended that additional farm management be offered. Recommended courses would be farm cost analysis and labor-management relations.

If students are going into such jobs as agricultural sales or elevator operation, additional study in sales and merchandising, business organization and management, and agricultural chemicals is recommended.

Students seeking employment with public or private organizations doing research should have the opportunity to take additional studies in plant breeding, agricultural chemicals, advanced crop botany, and plant diseases.

Other students may wish to take additional study in other subjects, such as journalism or religion in preparation for a career as an agricultural journalist or an agricultural missionary. In special cases, such as elevator operation where the business is also engaged in feed sales, it may be desirable to combine this curriculum with some studies in animal husbandry or poultry. Courses in feeds and feeding or livestock, dairy, or poultry production would be desirable for such an occupation.

COURSE OUTLINES

The courses which follow are intended to suggest the content which might be taught in the curriculum. The materials suggested provide a practical and attainable coverage of the field and have been reveiwed by experienced instructors in successful crop and fruit production technical education programs and by experts representing employers of these technical graduates.

It is expected that these materials will be modified in some measure to fill the needs defined by local advisory committees and to take advantage of special interests and capabilities of the teaching staff in any particular institution; but the implied level, quality, and completeness of the program should not be compromised.

At the end of each course is a list of text and reference materials. Each should be analyzed for its content and pertinency; new and more suitable ones should be substituted if they are available. The information needed to cover a particular course in technician educating curriculums, particularly the technical specialty courses, are almost never available in one textbook; hence the multiple listing of references. They usually should be considerably augmented by the current materials from manufacturers, trade journals, technical societies and suppliers of apparatus and services in the special field of applied science being studied.

Suggested visual aids are listed for many courses. Each should be used when pertinent and when its use will teach more efficiently than any other method. *Excessive showing of films at the expense of well prepared lectures and demonstrations is to be avoided.* The suggested outside study periods may well be used instead of class lecture time for the showing of some films. All visual aids should be examined by the instructor before they are shown. Those listed after courses show name and address of supplier, size in mm., minutes required for showing, and whether they are sound or silent. This provides the necessary information for selection to fit projection equipment.

It is expected that the experienced instructor will make liberal use of charts, slides, models, samples, and specimens which illustrate special technical aspects of the subject. These usually are accumulated from the experience of previous laboratory or lecture preparations of the instructor, and should be updated regularly when new developments require it. They are too specific for any attempt to be made to list them in this suggested guide.

The laboratory sessions suggested in the curriculum outline and course descriptions are not necessarily intended to be a single session, but rather as total hours of laboratory per week, to be scheduled in reasonable and effective increments. For example, a 6-hour laboratory total per week for a course might be scheduled as three 2-hour sessions or two 3-hour sessions, or any other divisions of laboratory time that seems appropriate.

Technical Specialty Courses

Cereal Crops

Hours Required

Class, 2; Laboratory, 3.

Course Description

A comprehensive course in the growth characteristics, cultural practices, and the marketing of cereal crops. Special emphasis is placed on the relationship of cultural practices and environment to market quality. In the laboratory, the student will be given an opportunity to gain actual experience in identifying, grading, and determining the market quality of cereals and cereal products. Comprehensive use will be made of quality testing devices and seed handling machines. In addition, provision is made for visits to marketing agencies and processing plants.

The student is assigned related readings which correspond with current class discussions. This material will serve as a supplement to class lectures, allowing the material to be covered in greater detail. A syllabus containing these related readings and laboratory assignments will be provided the student at the beginning of the semester.

Demonstration plots are maintained so the student is able to observe the growth habits of the different varieties of cereals and how they respond to various cultural practices and environmental conditions.

Major Divisions

		Class hours
I.	Importance of Cereal Crops	2
II.	Botanical Characteristics of Cereals	6
III.	Environment and Growth of Cereal Crops	4
IV.	Corn Production	4
V.	Wheat Production	4
VI.	Oat Production	2
VII.	Barley Production	2
VIII.	Grain Sorghum Production	2
IX.	Rice Production	2
X.	Rye Production	2
XI.	Marketing of Grain	2
	Total	32

Units of Instruction

I. Importance of Cereal Crops
  A. Utilization as a world food supply
    1. Geography of production
    2. Consumption
      a. Nutritient composition
      b. Geographic distribution of consumption
    3. World trade in cereals
  B. Use as animal food
    1. Grain crops
    2. Forage crops
      a. Hay
      b. Pasture
      c. Silage
      d. Soilage
  C. Relationship of the various crop belts to animal production
  D. Nonfood uses
    1. Industrial
    2. Crop rotations
      a. Cash crops
      b. Feed crops
II. Botanical Characteristics of Cereals
  A. Roots
    1. Types of roots
      a. Primary roots
      b. Coronal roots
      c. Aerial roots
    2. Length of root systems
    3. Water and nutrient absorption
  B. Stems
    1. Structure
    2. Functions
    3. Tillering
      a. Effect of weather
      b. Effect of mowing and grazing
    4. Changes occurring during growth
    5. Lodging
      a. Relationship to morphological characteristics
      b. Relationship to light
      c. Relationship to nutrition
      d. Relationship to moisture
      e. Relationship to stem pests
  C. Leaves
    1. Structure
    2. Function
      a. Photosynthesis
      b. Storage
      c. Transpiration
    3. Effect of leaf reduction on growth
    4. Effect of foliar disease and pests on growth
  D. Inflorescence
    1. Structure
      a. Spikes and panicles
      b. Spikelets
      c. Florets
    2. Unisexual flowers
    3. Pollination
      a. Self pollination
      b. Cross pollination
  E. Seeds
    1. Structure of cereal seeds
    2. Germination
    3. Conditions affecting germination

    4. Dormancy
    5. Longevity

III. Environment and Growth of Cereal Crops
  A. Cycle of plant growth
    1. Germination
    2. Seedling growth
    3. Active or developmental growth
    4. Reproduction
    5. Maturation
    6. Dormancy
  B. Environmental factors influencing growth
    1. Soil
      a. Fertility
      b. pH
      c. Structure
    2. Moisture
      a. Requirements of cereals
      b. Distribution of rainfall
    3. Temperature
      a. Warm season cereals
      b. Cool season cereals
      c. Length of growing season
    4. Humidity
      a. Relationship to transpiration
      b. Relationship to plant diseases
    5. Light interval and intensity
    6. Wind
      a. Cross pollination
      b. Lodging

IV. Corn Production
  A. Geographical distribution of production
  B. Uses of corn
    1. Animal feed use
    2. Corn in the human diet
    3. Industrial uses
  C. Characteristics of the different types of corn
    1. Sweet corn
    2. Pop corn
    3. Flint corn
    4. Dent corn
    5. Flour corn
    6. Pod corn
  D. Varieties
    1. Open pollinated
    2. Hybrids
  E. Adaptation
    1. Temperature
    2. Moisture
    3. Length of growing season
    4. Light
    5. Soil
  F. Cultural practices
    1. Seedbed preparation
    2. Seeding
      a. Methods
      b. Rates
      c. Dates
    3. Fertilization
      a. Manures and fertilizers
      b. Fertilizer practices
      c. Effect on yields
      d. Deficiencies
    4. Irrigation
      a. Applications
      b. Intervals
      c. Cultivation for water penetration
    5. Weed control
  G. Harvesting
    1. Methods
      a. Picker-shellers
      b. Corn combines
    2. Determining when to harvest
    3. Drying high moisture corn
  H. Insect pests of corn
    1. Soil inhabiting pests
    2. Leaf, stalk, and ear insects
  I. Corn diseases
  J. Costs of production

V. Wheat Production
  A. Geographical distribution of production
    1. Spring wheat areas
    2. Winter wheat areas
  B. Uses of wheat
    1. Human food
    2. Livestock feed
    3. Industrial uses
  C. Types of wheat
    1. Common
    2. Club
    3. Durum wheat
    4. Poulard
    5. Polish
    6. Emmer
    7. Einkorn
    8. Spelt
  D. Adaptation
    1. Temperature
      a. Winter hardiness
      b. Lack of winter hardiness

        2. Vernalization
        3. Moisture
        4. Light
        5. Soil
    E. Cultural practices
        1. Seedbed preparation
        2. Seeding
            a. Methods
            b. Rates
            c. Dates
        3. Fertilization
            a. Fertilizer practices
            b. Effect on yields
            c. Effect on milling quality
            d. Relationship to lodging
        4. Growing wheat under irrigation
        5. Fallowing
            a. Methods of fallowing
            b. Effect on nutrient buildup
            C. Effect on water conservation
        6. Weed control
    F. Harvesting
        1. Method
        2. Determining when to harvest
    G. Insect pests of wheat
    H. Wheat diseases
    I. Classes of wheat (characteristics, geography of production and milling qualities)
        1. Hard red winter
        2. Hard red spring
        3. Soft red spring
        4. White
        5. Durum
    J. Varieties
    K. Costs of production
    L. Milling of wheat
        1. Selecting milling wheat
        2. Processes in milling
        3. Factors affecting milling quality

VI. Oat Production
    A. Geographical distribution of production
    B. Uses of oats
        1. Livestock feed
        2. Human food
        3. Industrial uses
    C. Adaptation
        1. Temperature
        2. Moisture
        3. Soil
        4. Photoperiodic response
    D. Cultivated oat species
        1. Avena byzantina
        2. Avena sativa spp. diffusa
    E. Noncultivated oat species
        1. Avena barbata
        2. Avena fatua
    F. Cultural practices
        1. Seedbed preparation
        2. Seeding
            a. Fall sown oats
            b. Spring sown oats
        3. Fertilization
        4. Growing oats under irrigation
        5. Weed control
    G. Harvesting
    H. Insect pests of oats
    I. Oat diseases
    J. Varieties
    K. Costs of production

VII. Barley Production
    A. Geographical distribution of production
    B. Uses of barley
        1. Human food
        2. Animal feed
        3. Industrial uses
    C. Adaptation
        1. Temperature
        2. Moisture
        3. Light
        4. Soil
    D. Types of barley
        1. Hordeum vulgare
        2. Hordeum distichum
        3. Hordeum irregular
    E. Cultural practices
        1. Seedbed preparation
        2. Seeding
        3. Fertilization
        4. Growing barley under irrigation
    F. Harvesting
    G. Insect pests of barley
    H. Barley diseases
    I. Varieties
    J. Costs of production
    K. Malting barley
        1. Areas of production
        2. Conditions necessary for production
        3. Characteristics of malt barley
        4. Effect of environment on malting quality

        5. Malting process

VIII. Grain Sorghum Production
    A. Geographical distribution of production
    B. Adaptation
        1. Corn vs. sorghum growing
        2. Length of growing season
        3. Temperature
        4. Humidity
        5. Moisture
        6. Soil
    C. Sorghum types
        1. Grain sorghums
        2. Forage sorghums
        3. Grass sorghums
        4. Broomcorn
    D. Grain sorghums
        1. Kaffir
        2. Hegari
        3. Milo
        4. Feterita
        5. Durra
        6. Shallu
        7. Kaoliang
    E. Cultural practices
        1. Crop rotations
        2. Seedbed preparation
        3. Seeding
        4. Fertilization
        5. Growing sorghums under irrigation
        6. Weed control
    F. Harvesting
    G. Insect pests of sorghums
    H. Sorghum diseases
    I. Sorghum varieties
    J. Costs of production

IX. Rice Production
    A. Geographical distribution of production
    B. Adaptation
        1. Temperature
        2. Photoperiodic response
        3. Water
            a. Submerged rice
            b. Nonsubmerged rice
            c. Amount
            d. Quality
        4. Soil
        5. Length of growing season
    C. Rice types
        1. Short grain types
        2. Medium grain types
        3. Long grain types
    D. Cultural practices
        1. Using rice to reclaim alkali soils
        2. Crop rotations
        3. Seedbed preparation
        4. Seeding
        5. Supplying water
        6. Fertilization
        7. Weed control
    E. Harvesting
    F. Insect pests of rice
    G. Rice diseases
    H. Varieties
    I Costs of production
    J. Milling of rice

X. Rye Production
    A. Geographical distribution
    B. Adaptations
        1. Temperature
        2. Moisture
        3. Soil
    C. Cultural practices
        1. Seedbed preparation
        2. Seeding
        3. Harvesting
    D. Varieties
    E. Diseases
    F. Insect pests
    G. Milling of rye

XI. Marketing of Grain
    A. Storage
        1. Facilities
        2. Drying high moisture grains
            a. Temperature
            b. Time
            c. Effect on quality
        3. Spoilage in storage
            a. Relationship of moisture to spoilage
            b. Relationship of temperature to spoilage
            c. Relationship of molds and fungi to spoilage
            d. Relationship of fat content to spoilage
        4. Preventing spoilage
            a. Maintaining proper moisture level
            b. Aeration
            c. Stored grain pest control
            d. Use of inert gases

B. Marketing facilities
    1. Elevators
        a. Cooperatives
        b. Independent
        c. Commercial line
        d. Mill
    2. Brokers or commission houses
    3. Terminal markets

C. Marketing methods
    1. Cash
    2. Futures
    3. Hedging

Suggested Laboratory Projects (48 hours)

1. Study the botanical characteristics and identify the small grains. (3 hours)
2. Study the morphological characteristics of the wheat classes and identify the varieties. (3 hours)
3. Study the morphological characteristics and identify the varieties of barley. (3 hours)
4. Study the morphological characteristics and identify the sorghum types. (3 hours)
5. Visit a grain exchange. (3 hours)
6. Test the milling and baking quality of wheat. (3 hours)
7. Determine the moisture content of grain. (3 hours)
8. Determine the holding ability of grain. (3 hours)
9. Grade corn. (3 hours)
10. Grade wheat. (3 hours)
11. Grade barley. (3 hours)
12. Identify and determine insect infestations of grain and grain products. (3 hours)
13. Calibrate a grain drill and plant cereal plots. (3 hours)
14. Visit a grain elevator (3 hours)
15. Treat cereal plots with herbicides. (3 hours)
16. Identify corn types and judge ear corn. (3 hours)

Texts and References

ALDRICH *and* LENG, *Modern Corn Production*
DELORIT *and* AHLGREN, *Crop Production*
HUGHES *and* HENSON, *Crop Production Principles and Practices*
LEONARD *and* MARTIN, *Cereal Crops*
PEARSON, *Principles of Agronomy*

Figure 14.—One of the most important operations in raising deciduous fruit is pruning. Here a student is learning the correct cutting procedures.

Deciduous Fruit Production

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of the principles and practices involved in the production of deciduous fruits. Emphasis is given to the selection of the orchard, cultural operations, fruit handling and marketing. Laboratory periods provide time for practice and observation of various cultural and management operations.

A one-semester course does not allow much time to consider all species, varieties, and their production problems. The instructor must evaluate his local conditions and determine which material is pertinent. The course may be offered in either the fall or spring semester. Local conditions will be the determining factor. The various topics will be discussed in a different order depending upon the semester in which the course is offered. Where production is specialized, more time may be provided by eliminating the more general information.

Laboratory periods provide time for practice and observation of various cultural and management operations.

Where it is not possible to demonstrate practices in the school orchard, more time will have to be spent in the laboratory using audio and visual aids. Fruitwood, fruit, and other plant materials may be saved and stored for future use.

Major Divisions

		Class hours
I.	The Fruit Industry	2
II.	Fruit Handling and Marketing	4
III.	Selection of Production Unit	4
IV.	Fruiting Habits	4
V.	Soil Management Practices	6
VI.	Tree Care	8
VII.	Problems of the Industry	4
	Total	32

Units of Instruction

- I. The Fruit Industry
  - A. Species considered
  - B. Areas of production
    - 1. National
    - 2. Regional
    - 3. Local
  - C. Local area
    - 1. Importance
    - 2. Adaptation
      - a. Advantages
      - b. Disadvantages
  - D. Economics
    - 1. Production costs
    - 2. Labor
      - a. Requirements
      - b. Supply
  - E. Trends and changes
    - 1. National
    - 2. Regional
    - 3. Local

- II. Fruit Handling and Marketing
  - A. Uses
    - 1. Fresh
    - 2. Canned
    - 3. Dried
    - 4. Frozen
    - 5. By-products
  - B. Market outlets
    - 1. Cash buyers
    - 2. Cooperatives
    - 3. Consignment
    - 4. Retail
  - C. Factors affecting quality
    - 1. Varieties
    - 2. Climate
    - 3. Size
    - 4. Maturity
    - 5. Condition
      - a. Diseases
      - b. Insect damage
      - c. Physiological defects
  - D. Orchard practices
    - 1. Picking
    - 2. Hauling
    - 3. Labor Management
  - E. Packing house
    - 1. Processing
    - 2. Storage
      - a. Temperature
      - b. Atmosphere
    - 3. Costs
  - F. Sales
    - 1. Methods
    - 2. Distribution

- III. Selection of Production Unit
  - A. Site
    - 1. Climate
    - 2. Topography
    - 3. Soil
      - a. Type
      - b. Fertility
      - c. Erosion
      - d. Management practices required
    - 4. Water supply
      - a. Amount
      - b. Quality
      - c. Availability
      - d. Cost
  - B. Establishing the orchard
    - 1. Planting systems
    - 2. Selection of trees
      - a. Variety
      - b. Rootstock
      - c. Cost
    - 3. Economics
      - a. Close planting
      - b. Intercropping
    - 4. Training young trees
    - 5. Cost
  - C. Established orchard
    - 1. System of planting
    - 2. Soil conditions

        - a. Erosion
        - b. Fertility
        - c. Weeds
        - d. Compaction
        - e. Irrigation system
    - 3. Condition of trees
        - a. Variety
        - b. Age
        - c. Uniformity
        - d. Productivity
        - e. Health
        - f. Estimated productive life
    - 4. Management practices
        - a. Current
        - b. Recommended
    - 5. Price

- IV. Fruiting Habits
    - A. Species concerned
    - B. Bearing habits
        - 1. Types of wood
        - 2. Location of buds
        - 3. Fruit and formation
            - a. Season
            - b. Tree condition
    - C. Pollination
        - 1. Season of bloom
        - 2. Use of bees
        - 3. Cross pollination
    - D. Fruit morphology
    - E. Relationship to management practices
        - 1. Pruning
        - 2. Fertilizing
        - 3. Thinning
        - 4. Spraying
        - 5. Frost protection

- V. Soil Management Practices
    - A. Cultivation
        - 1. Value
        - 2. Methods
    - B. Fertilization
        - 1. Nutrient requirement
        - 2. Materials used
        - 3. Methods of application
        - 4. Green manure crops
        - 5. Cost
    - C. Irrigation
        - 1. Requirements
        - 2. Soil characteristics
        - 3. Methods of application
        - 4. Frost protection
        - 5. Moisture testing
        - 6. Cost
    - D. Soil protection
        - 1. Cover cropping
        - 2. Irrigation control
        - 3. Weed control

- VI. Tree Care
    - A. Pruning
        - 1. Responses
        - 2. Systems
        - 3. Labor requirement
        - 4. Cost
    - B. Insects and Diseases
        - 1. Diseases
            - a. Economic importance
            - b. Spray programs
        - 2. Insects
            - a. Economic importance
            - b. Spray programs
            - c. Integrated control (mites, pear psylla)
            - d. Sterilized males
        - 3. Orchard sanitation
        - 4. Chemical residues on crops
    - C. Thinning
        - 1. Value
        - 2. Season
        - 3. Methods
            - a. Hand
            - b. Relation to pruning
            - e. Chemical
    - D. Propagation
        - 1. Replacement trees
        - 2. Top-working
            - a. Varieties
            - b. Methods
            - c. Subsequent care
    - E. Frost protection
        - 1. Losses
        - 2. Methods
        - 3. Cost

- VII. Problems of the Industry
    - A. Consumer
    - B. Competition
        - 1. Local
        - 2. Industry
        - 3. Labor
    - C. Sales methods
    - D. Mechanization

    1. Cultural operations
    2. Effect on labor
  - E. Cost of production

Suggested Laboratory Projects (48 hours)

1. Make a study of species and varieties and an evaluation of quality as related to cultural operations. (3 hours)
2. Judge the fruit of various species. (3 hours)
3. Take a field trip to observe harvesting and fruit handling. (3 hours)
4. Take a field trip to a local packing house. (3 hours)
5. Lay out an orchard and plant trees. (3 hours)
6. Study fruit wood, bud formation, and fruit morphology. (3 hours)
7. Apply fertilizers and lay out test plots. (3 hours)
8. Take a field trip to observe effects of cultivation, cover cropping, and irrigation on erosion. (3 hours)
9. Study soil management, moisture testing, soil compaction, and water penetration. (3 hours)
10. Study the mechanics of pruning. (3 hours)
11. Practice pruning. (3 hours)
12. Study mixing and application of materials used in pest control. (3 hours)
13. Practice top-working old trees. (3 hours)
14. Test thermometers and practice operating frost control equipment. (3 hours)
15. Analyze cost of production studies. (3 hours)
16. Practice orchard judging. (3 hours)

Texts and References

CHANDLER, *Deciduous Orchards*

EDMOND *and* others, *Fundamentals of Horticulture*

JANICK, *Horticultural Science*

SCHEER *and* JUERGENSON, *Approved Practices In Fruit Production*

SCHNEIDER *and* SCARBOROUGH, *Fruit Growing*

Field Crops

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of the characteristics of field crops and their response to environmental conditions with emphasis on production and marketing problems. Laboratory periods include field trips to commercial farms and processing plants in addition to work in identification, grading, and evaluation of crop products.

This course is designed to impart a working knowledge of the fundamentals of the growth of crop plants. Emphasis will be placed upon the relationship of environment to the yield and quality of field crops of major importance. The selection of the proper crops to grow and the manipulation of environment to enhance crop yields will be studied.

Since this is a basic course which will develop a background of information the student will utilize in future classes, the application of principles will be stressed. Class discussions will emphasize the practical application of information in recognizing and dealing with crop production problems.

Laboratory problems will provide the student with an opportunity to study the morphological characteristics and adaptation of the various field crops. Also, laboratory exercises will stress the importance of producing a crop of high market value. Students will develop a working knowledge of market quality and its relationship to environmental and cultural practices.

Note.—Examples of crops to be studied should be selected to suit local or regional interests.

Major Divisions

		Class hours
I.	Classification of Crop Plants	2
II.	Plant Structure and Function	2
III.	Response of Crops to Environment	4
IV.	Crop Rotation Practices	2
V.	Seeds and Seeding	2
VI.	Cultural Practices	2
VII.	Harvesting Field Crops	2
VIII.	Production of Specific Field Crops	16
	Total	32

Units of Instruction

- I. Classification of Crop Plants
  - A. Botanical classification
    1. Binomial system.
    2. Major field crop families
       - a. Gramineae

    - b. Leguminosae
    - c. Chenopodiaceae
    - d. Malvaceae
    - e. Linaceae
    - f. Solanaceae
    - g. Compositae
- B. Agronomic classification
  - 1. Cereal crops
  - 2. Large seeded legumes
  - 3. Forage crops
  - 4. Seed crops
  - 5. Fiber crops
  - 6. Sugar crops
  - 7. Oil crops
  - 8. Stimulant and medicinal crops
- C. Special use classification
  - 1. Emergency crops
  - 2. Companion crops
  - 3. Green manure crops
  - 4. Cover crops
  - 5. Soiling crops
  - 6. Silage crops
- D. Life span classification
  - 1. Annuals
  - 2. Biennials
  - 3. Perennials
- E. Thermo classification
  - 1. Warm season crops
  - 2. Cool season crops

II. Plant Structure and Function
- A. Roots
  - 1. Kind of roots
  - 2. Structure of roots
  - 3. Distribution of roots
  - 4. Absorption of water and nutrients
  - 5. Conduction of water and nutrients
  - 6. Storage of food
- B. Stems
  - 1. Kinds of stems
  - 2. Structure of stems
  - 3. Modified stems
  - 4. Conduction of water and nutrients
  - 5. Storage of food
- C. Leaves
  - 1. Kinds of leaves
  - 2. Structure of leaf
  - 3. Photosynthesis
  - 4. Transpiration
- D. Flowers
  - 1. Kinds of flowers
  - 2. Structure of the typical flower
  - 3. Sexual reproduction
- E. Seeds
  - 1. Kinds of seeds (Monocotyledons-Dicotyledons)
  - 2. Structure of the seed
  - 3. Physiological processes of seeds
  - 4. Germination
  - 5. Dormancy

III. Response of Crops to Environment
- A. Response to climatic conditions
  - 1. Temperature
  - 2. Moisture
  - 3. Day length and light intensity
  - 4. Length of growing season
  - 5. Air movements
- B. Response of crops to soil conditions
  - 1. Structure
  - 2. Fertility
  - 3. Soil pH
- C. Response of crops to production hazards
  - 1. Insect pests
  - 2. Disease
  - 3. Competitive plant growth
- D. Crop adaptation
- E. Effect of fallowing on plant growth

IV. Crop Rotation Practices
- A. Factors affecting crop rotation
  - 1. Maintaining productive soils
  - 2. Offsetting production hazards
  - 3. Utilizing land, labor, and capital
  - 4. Spreading risk and balancing income
- B. Cropping systems and soil conservation
  - 1. Soil building crops
  - 2. Soil protecting crops
  - 3. Soil exposing crops
- C. Crop sequences
  - 1. Grass-legume crops
  - 2. Green manure crops
  - 3. Handling crop residues
  - 4. Increasing yields of cash crops
  - 5. Length of crop rotations
- D. Green manure crops
  - 1. Importance of organic matter
  - 2. Crops used
  - 3. Decomposition of crop residue
  - 4. Effect on subsequent crops

V. Seeds and Seeding
- A. Enhancing germination through seedbed preparation

        1. Getting rid of crop residues
        2. Mellowing and firming
        3. Irrigation
    - B. Methods of planting
        1. Broadcast planting
        2. Planting with grain drill and grassland seeders
        3. Planting with row crop planters
        4. Banding
    - C. Depth of planting
        1. Kind of crop
        2. Soil moisture
        3. Soil type
    - D. Seeding rates
        1. Kind of crop
        2. Crop use
        3. Crop quality
        4. Seed quality
        5. Condition of seedbed
        6. Soil productivity
        7. Soil moisture
        8. Production hazards
    - E. Seeding dates
        1. Soil conditions
        2. Climatic conditions
        3. Production hazards
        4. Marketing considerations
    - F. Characteristics of good seed
        1. Purity
        2. Germination
        3. Free from damage
        4. Free from detrimental characteristics
        5. Adaptablility

VI. Cultural Practices
- A. Aiding plants in getting established
    1. Preemergence cultivation
    2. Preemergence application of herbicides and insecticides
- B. Stimulating crop growth
    1. Conservation of moisture
    2. Tillage for root growth
    3. Drainage of excess moisture
    4. Reducing plant populations to an optimum level
    5. Irrigation
    6. Fertilization
    7. Weed control
    8. Insect control

VII. Harvesting Field Crops
- A. Timing the harvest
    1. Yield
    2. Quality
- B. Harvesting methods
    1. Seed crops
    2. Forage crops
    3. Fiber crops
    4. Root and tuber crops
- C. Post harvest care of crops
    1. Curing
    2. Preventing contamination
    3. Protecting from damage
    4. Preventing shrinkage losses
    5. Transportation

VIII. Production of Specific Field Crops
- A. Oil crops (soybeans, safflower, flax, castorbeans, sunflower)
    1. Production areas
    2. Adaptation
    3. Varieties
    4. Cultural practices
    5. Harvesting
    6. Cost of production
    7. Marketing
- B. Fiber crops (cotton)
    1. Production areas
    2. Adaptation
    3. Varieties
    4. Cultural practices
    5. Harvesting
    6. Costs of production
    7. Marketing
- C. Sugar crops (sugar beets-sugar cane)
    1. Production areas
    2. Adaptation
    3. Varieties
    4. Cultural practices
    5. Harvesting
    6. Costs of production
    7. Marketing
- D. Field beans
    1. Production areas
    2. Adaptation
    3. Varieties
    4. Cultural practices
    5. Harvesting
    6. Cost of production
    7. Marketing
- E. Potatoes
    1. Production areas
    2. Adaptation

3. Varieties
4. Cultural practices
5. Harvesting
6. Costs of production
7. Marketing

Suggested Laboratory Projects (48 hours)

Note—Visits should be made to points of interest which reflect area or regional practice, and which provide experiences equivalent to the following suggested exercises:

1. Study and identify the morphological characteristics of the major field crops. (6 hours)
2. Practice classing, ginning, and determining the percent lint of cotton. (3 hours)
3. Visit a cotton gin. (3 hours)
4. Extract vegetable oils and analyze their market quality. (3 hours)
5. Identify types and varieties of oil bearing seeds and determine their grade. (3 hours)
6. Visit a vegetable oil mill. (3 hours)
7. Identify and grade field beans. (3 hours)
8. Visit a farm growing dry beans and a bean processing house. (3 hours)
9. Visit a sugar mill. (3 hours)
10. Visit a farm growing potatoes and a potato processing shed. (3 hours)
11. Identify common green manure crops. (3 hours)
12. Identify the pests of stored field crops. (3 hours)
13. Identify the common diseases of field crops. (3 hours)
14. Determine the effect of fertilizers on test plots of field crops. (6 hours)

Texts and References

ALLARD *and others*, *Manual of California Field Crops*
DELORIT *and* AHLGREN, *Crop Production*
MARTIN *and* LEONARD, *Principles of Field Crop Production*
PEARSON, *Principles of Agronomy*

Forage Crops

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the adaptation, utilization, and culture of those crops grown for pasture, hay, silage and soilage. During the laboratory periods, students will learn to identify the various species of forage and to evaluate those characteristics associated with their feeding value.

The student will be assigned periodic related readings which correspond to the current unit of instruction. These assignments along with the laboratory exercises will be given the student in the form of a syllabus upon his entrance into the class.

The student will make field visits to pastures to determine their carrying capacity and quality and to learn how cultural practices affect these factors.

A plant collection of the important forage grown in the local area or region is required of all students.

Major Divisions

		Class hours
I.	Distribution and Importance of Forages	2
II.	Considerations in Planning a Forage Program	3
III.	Irrigating Forage Crops	4
IV.	Alfalfa Production	3
V.	Permanent Pastures	4
VI.	The Use of Sorghums for Forage	2
VII.	Legumes for Rotation, Temporary, and Permanent Pastures	4
VIII.	Grasses for Rotation, Temporary, and Permanent Pastures	4
IX.	Hay and Haymaking	4
X.	Silage	2
	Total	32

Units of Instruction

I. Distribution and Importance of Forages
  A. Types of forage
    1. Native pastures
    2. Tame pastures
    3. Hay crops
    4. Silage crops
    5. Soilage crops
    6. Succulage
  B. Distribution
    1. Hay belt
    2. Grain belt
    3. Uncultivated pasture and grazing lands

- C. Importance
  - 1. Amount in animal diets
  - 2. Utilization of marginal land
  - 3. Crop rotation
  - 4. Soil conservation
    - a. Soil protection
    - b. Soil drainage
    - c. Organic matter
    - d. Soil microorganisms

II. Considerations in Planning a Forage Program
- A. Climatic factors
  - 1. Temperature
  - 2. Rainfall and moisture
  - 3. Humidity
    - a. Evapotranspiration
    - b. Disease
  - 4. Light
  - 5. Length of growing season
- B. Animal factors
  - 1. Forage requirements of animals
    - a. Beef cattle
    - b. Dairy cattle
    - c. Sheep
    - d. Horses
    - e. Hogs
    - f. Chickens and turkeys
  - 2. Purpose for which livestock is being fed
    - a. Maintenance
    - b. Breeding stock
    - c. Fat stock
    - d. Lactating animals
  - 3. Feed conversion and growth rates
  - 4. Factors affecting intake
  - 5. Grazing habits
- C. Plant factors
  - 1. Palatability
  - 2. Response to grazing
  - 3. Response to climatic environment
  - 4. Response to soil environment
  - 5. Yielding ability
  - 6. Digestibility
  - 7. Nutritional value
  - 8. Detrimental aspects
    - a. Toxic effects
    - b. Bloat problems
    - c. Aggressiveness
  - 9. Growth habits
    - a. Growing season
    - b. Annuals, biennials, perennials
    - c. Longevity of production during the growing season
  - 10. Adaptability to varying forage uses
  - 11. Suitability to various curing and storage methods
- D. Environmental factors
  - 1. Thermatic conditions
  - 2. Moisture conditions
  - 3. Soil environment
  - 4. Topography
  - 5. Length of growing season
  - 6. Duration and intensity of light periods
- E. Suitability to the farming program
  - 1. Adaptability to varying farm uses
  - 2. Cash crop *v.* feed crop
  - 3. Labor requirements
  - 4. Equipment requirements
  - 5. Utilization of land
  - 6. Effect on soil conservation
  - 7. Costs of production in relation to returns
  - 8. Special cultural problems

III. Irrigating Forage Crops
- A. Methods of applying water
  - 1. Wild flooding
    - a. Description of method
    - b. Advantages
    - c. Limitations
    - d. Land preparation
  - 2. Contour check
    - a. Description of method
    - b. Advantages
    - c. Limitations
    - d. Land preparation
  - 3. Border check
    - a. Description of method
    - b. Advantages
    - c. Limitations
    - d. Land preparation
  - 4. Sprinklers
    - a. Description
    - b. Advantages
    - c. Limitations
    - d. Land preparation
- B. Selecting the best method
  - 1. Soil type
  - 2. Topography
  - 3. Water costs
  - 4. Labor costs

5. Alkalinity of water and soil
6. Water supply
    a. Method of Supplying
    b. Amount available
    c. Water quality
7. Crop to be grown
8. Maintenance and depreciation of the system

C. Constructing the system
  1. Sprinkler installations
      a. Number, type, and size of sprinklers
      b. Spacing the sprinklers
      c. Pump and supply lines
  2. Supply lines and ditches for flooding methods of irrigation
      a. Temporary lines
      b. Permanent lines
      c. Dirt ditches
      d. Concrete ditches
      e. Plastic lined ditches
      f. Turn out structures
  3. Determining the size of checks for flood irrigation
      a. Length of run
      b. Width of run
      c. Soil types
      d. Percent slope
      e. Volume of water
      f. Crop to be grown
  4. Pumps
      a. Types
      b. Size
      c. Power requirements
  5. Laying out the field for flooding methods
      a. Equipment
      b. Leveling
      c. Establishing borders
      d. Providing for drainage of excess water

D. Applying water
  1. Determining the amount
      a. Field capacity of the soil
      b. Time of the year
      c. Stage of growth
      d. Reaction of the crop
  2. Calculating the amount of water needed
      a. Acre inches
      b. Miners inches
      c. Gallons per minute
  3. Reuse of tail water
  4. Controlling the flow of water
  5. Costs of irrigating

E. Special problems in applying water
  1. Salt content of water
  2. Alkalinity problems of the soil
  3. Burrowing rodents
  4. Disease problems
  5. High and low spots
  6. Drainage
      a. Hardpans and claypans
      b. Tiling
  7. Soil temperature
  8. Leaching
  9. Applying fertilizers in water

IV. Alfalfa Production

A. Distribution and adaptation
  1. Geographic distribution
  2. Adaptation
      a. Climate
      b. Soil
      c. Water

B. Seeds and Seeding
  1. Time of seeding
  2. Method of seeding
  3. Depth of seeding
  4. Rate of seeding
  5. Use of a nurse crop

C. Fertilizer requirements
  1. Phosphorous
  2. Sulphur
  3. Potassium
  4. Nitrogen
  5. Use of manures

D. Soil conditions and related problems
  1. Alkali
  2. Plowsoles
  3. Hardpans and Claypans
  4. Unproductive areas
  5. Longevity of stands
  6. Interseeding companion crops
  7. Plowing under old stands

E. Types and varieties
  1. Alfalfa groups
      a. Common group
      b. Variegated group
      c. Turkistan group
      d. Nonhardy group
      e. Hybrid alfalfa
      f. Rhizomatous alfalfa

2. Varieties
a. Growth habits
b. Disease, insect, and nematode resistance
c. Feed quality
d. Yields
F. Harvesting procedures
1. Pasturing
2. Haying
3. Ensiling
4. Soiling
G. Alfalfa quality
1. Stage of maturity
a. Determining 10 percent bloom
b. Chemical composition at various stages
2. Quality in relationship to cutting
3. Quality in relationship to curing methods
4. Effect of season on quality
5. Effect of variety on quality
6. Comparison of harvesting methods
7. Comparison of conditioned and non-conditioned hay
H. Production problems
1. Insect pests
2. Diseases
3. Weeds
I. Inoculation of alfalfa and other legumes
1. Symbiosis
a. Nitrogen fixing bacteria
b. Mutual cooperation between plant and bacteria
2. Inoculation groups
a. Alfalfa group
b. Clover group
c. Pea and vetch group
d. Bean group
e. Soybean group
f. Cowpea group
g. Lupine group
h. Specific plant groups
3. Commercial inoculation
a. Jelly or agar bases
b. Liquids
c. Humus or peat
d. Noculized seed
4. Reasons for inoculating
a. Prevention of nitrogen starvation
b. Lessens nitrogen demand
c. Increase crop yield
d. Improves crop quality
e. Insures rich green manures
5. Effect of pH on nitrogen fixation

V. Permanent Pastures
A. Types of permanent pastures
1. Native pastures
2. Tame pastures
3. Irrigated permanent pastures
4. Dry farmed permanent pastures
5. Annual reseeding pastures
6. Perennial pastures
B. Adaptation of permanent pastures
1. Climatic adaptations
a. Rainfall
b. Soil
c. Temperature
2. Soil adaptations
a. Soil type
b. Soil profile
c. Soil fertility
d. Soil pH
C. Cultural practices
1. Seedbed preparation
2. Seeding procedures
a. Rates and dates
b. Methods and depth
3. Irrigation
a. Timing applications
b. Frequency of applications
c. Amount of water
d. Seasonal requirements
e. Irrigation methods
f. Relationship to other management practices
4. Weed control
5. Preventing clumping
a. Harrowing
b. Clipping
c. Grazing
6. Fertilization
a. Effect on yields
b. Effect on nutritional quality
c. Effect on animal intake
d. Determining plant needs
e. Timing applications
f. Liming
g. Using animal manures
7. Mowing
a. Coarse growing grasses
b. Winter feed

D. Grazing practices
  1. Estimating carrying capacity
  2. Grazing methods
  3. Frequency of grazing
  4. Stage of growth
    a. New pastures
    b. Established pastures
  5. Quality in relation to grazing
  6. Trampling
  7. Selective grazing
  8. Grazing habits of animals
  9. Intensity of grazing
  10. Duration of grazing period
  11. Mixed grazing
  12. Controlling bloat
  13. Poisoning problems
    a. Ergot poisoning
    b. Molybdenum poisoning
  14. Supplemental feeds
  15. Annual animal unit yield

E. Special problems
  1. Alkali spots
  2. Animal parasites and diseases
  3. Leaching
  4. Mosquito control

F. Permanent pasture mixes
  1. Advantages
    a. Lengthens the feeding period
    b. Balanced ration
    c. Bloat control
    d. Competitive weed control
  2. Planning the mixture
    a. Grazing habits of animal
    b. Food preferences of animal
    c. Nutritional value of plant
    d. Adaptation to climate conditions
    e. Growth habits of plants
    f. Soil conditions

G. Reseeding and renovation
  1. Methods of renovating
  2. Seeding in established stands
  3. Plowing under old stands

H. Costs
  1. Cost of preparing land
    a. Surveying
    b. Land grading
    c. Pump and well
    d. Distribution system
  2. Establishing the stand
    a. Labor
    b. Equipment
    c. Materials

VI. The Use of Sorghums for Forage
A. Distribution and adaptation
  1. Geographic distribution of production
  2. Adaptation
    a. Temperature
    b. Moisture
    c. Soil
    d. Length of growing season
B. Types and varieties
  1. Forage types
    a. Utilization
    b. Varieties
  2. Hybrid sorghums for pasture, hay, and silage
C. Cultural practices
  1. Seedbed preparation
  2. Seeding
    a. Dates and rates
    b. Drilling with grain drills
    c. Planting in rows
    d. Broadcasting
    e. Effect on forage quality
  3. Weed control
  4. Fertilizing
  5. Irrigation
    a. Timing and frequency
    b. Amount
D. Grazing
  1. Stage of maturity
  2. Frequency
  3. Quality of forage
  4. Animal unit yield
E. Haymaking
  1. Quality of sudan hay
  2. Yields
  3. Procedures
    a. Stage of maturity
    b. Mowing
    c. Windrowing
    d. Baling
  4. Costs
F. Sorgos for silage
  1. Quality
  2. Yields
  3. Procedures
G. Prussic acid poisoning
  1. Causes
  2. Preventing poisoning problems

        - a. Selection of proper variety
        - b. Timing planting dates
        - c. Deferred grazing
        - d. Early fall removal of livestock

VII. Legumes for Rotation, Temporary, and Permanent Pastures
- A. The true clovers
    - 1. Botanical characteristics
    - 2. The important pasture clovers
    - 3. Adaptation
        - a. Climate
        - b. Soil
    - 4. Varieties
    - 5. Seeding practices
        - a. Methods
        - b. Dates and rates of seeding
    - 6. Cultural practices
        - a. Control of pests and diseases
        - b. Irrigation
        - c. Fertilization
    - 7. Pasturing
    - 8. Use for hay, silage and soilage
    - 9. Mixtures
    - 10. Seed production
- B. The sweetclovers
    - 1. Botanical characteristics
    - 2. Species of important sweetclovers
    - 3. Adaptation
        - a. Climate
        - b. Soil
    - 4. Varieties
    - 5. Seeding practices
        - a. Methods
        - b. Dates and rates
    - 6. Cultural practices
        - a. Control of pests and diseases
        - b. Irrigation
        - c. Fertilization
    - 7. Pasturing
    - 8. Sweetclover poisoning
    - 9. Use for hay and silage
    - 10. Mixtures
    - 11. Seed production
- C. Birdsfoot trefoil
    - 1. Botanical characteristics
    - 2. Species of birdsfoot trefoil
    - 3. Adaptation
        - a. Climate
        - b. Soil
    - 4. Varieties
    - 5. Seeding practices
        - a. Methods
        - b. Dates and rates
    - 6. Cultural practices
        - a. Control of pests and disease
        - b. Irrigation
        - c. Fertilization
    - 7. Pasturing
    - 8. Use for hay and silage
    - 9. Mixtures
    - 10. Seed production
- D. Lespedeza
    - 1. Botanical characteristics
    - 2. Species of lespedeza
    - 3. Adaptation
        - a. Climate
        - b. Soil
    - 4. Varieties
    - 5. Seeding practices
        - a. Methods
        - b. Dates and rates
    - 6. Cultural practices
        - a. Control of pests and disease
        - b. Irrigation
        - c. Fertilization
    - 7. Pasturing
    - 8. Use for hay and silage
    - 9. Seed production
- E. Soybeans
    - 1. Botanical characteristics
    - 2. Adaptation
        - a. Climate
        - b. Soil
    - 3. Varieties
    - 4. Seeding practices
        - a. Methods
        - b. Dates and rates
    - 5. Cultural practices
        - a. Control of pests and disease
        - b. Irrigation
        - c. Fertilization
    - 6. Pasturing
    - 7. Use for hay and silage
    - 8. Mixtures
    - 9. Seed production
- F. Vetches
    - 1. Botanical characteristics
    - 2. Species of vetch
    - 3. Adaptation
        - a. Climate
        - b. Soil

4. Seeding practices
    a. Methods
    b. Dates and rates
5. Cultural practices
    a. Control of pests and disease
    b. Rotations
6. Use for hay and soilage
7. Mixtures
8. Seed production

VIII. Grasses for Rotation, Temporary, and Permanent Pastures
  A. Bluegrass
    1. Botanical characteristics
    2. Species of bluegrass used for forage
    3. Adaptation
      a. Climate
      b. Soil
    4. Varieties
    5. Seeding
      a. Methods
      b. Dates and rates
    6. Cultural practices
      a. Control of pests and disease
      b. Irrigation
      c. Fertilization
    7. Utilization as a forage crop
    8. Mixtures
    9. Seed production
  B. Bromegrass
    1. Botanical characteristics
    2. Species of bromegrass used for forage
    3. Adaptation
      a. Climate
      b. Soil
    4. Varieties
    5. Seeding
      a. Methods
      b. Dates and rates
    6. Cultural practices
      a. Control of pests and disease
      b. Irrigation
      c. Fertilization
    7. Utilization as a forage crop
    8. Mixtures
    9. Seed production
  C. Fescues
    1. Botanical characteristics
    2. Species of fescue used for forage
    3. Adaptation
      a. Climate
      b. Soil
    4. Varieties
    5. Seeding
      a. Methods
      b. Dates and rates
    6. Cultural practices
      a. Control of pests and disease
      b. Irrigation
      c. Fertilization
    7. Utilization as a forage crop
    8. Mixtures
    9. Seed production
  D. Ryegrasses
    1. Botanical characteristics
    2. Species of ryegrass used for forage
    3. Adaptation
      a. Climate
      b. Soil
    4. Varieties
    5. Seeding
      a. Methods
      b. Dates and rates
    6. Cultural practices
      a. Control of pests and disease
      b. Irrigation
    7. Utilization as a forage crop
    8. Mixtures
    9. Seed production
  E. Orchard grasses
    1. Botanical characteristics
    2. Adaptation
      a. Climate
      b. Soil
    3. Varieties
    4 Seeding
      a. Methods
      b. Dates and rates
    5. Cultural practices
      a. Control of pests and disease
      b. Irrigation
      c. Fertilization
    6. Utilization as a forage crop
    7. Mixtures
    8. Seed production
  F. Timothy
    1. Botanical characteristics
    2. Adaptation
      a. Climate
      b. Soil
    3. Varieties

    4. Seeding
        a. Methods
        b. Dates and rates
    5. Cultural practices
        a. Control of pests and disease
        b. Irrigation
        c. Fertilization
    6. Utilization as a forage crop
    7. Mixtures
    8. Seed production
G. Bermuda
    1. Botanical characteristics
    2. Adaptation
        a. Climate
        b. Soil
    3. Varieties
    4. Seeding
        a. Methods
        b. Dates and rates
    5. Cultural practices
        a. Control of pests and disease
        b. Irrigation
        c. Fertilization
    6. Utilization as a forage crop
    7. Mixtures
    8. Seed production
H. Cereals
    1. Botanical characteristics
    2. Species of cereals used for forage
        a. Wheat
        b. Rye
        c. Barley
    3. Adaptation
        a. Climate
        b. Soil
    4. Varieties
    5. Seeding
        a. Methods
        b. Dates and rates
    6. Cultural practices
        a. Control of pests and disease
        b. Irrigation
        c. Fertilization
    7. Utilization as a forage crop
    8. Mixtures

IX. Hay and Haymaking
A. Haying equipment
    1. Mowers
    2. Conditioners
    3. Rakes
    4. Balers
    5. Loaders
B. Characteristics of good hay
    1. Leafiness
    2. Leaf retention
    3. Fineness of stem
    4. Color
    5. Aroma
    6. Amount of foreign material
    7. Palatability
    8. Pliable texture
C. Grading hay
    1. Classes of hay
    2. Grades of hay
    3. Special grades of hay
D. Factors affecting hay quality
    1. Soil
        a. Soil nutrients
        b. Water holding capacity
        c. Effect of fertilization on nutrient composition
    2. Sage of growth
        a. Relationship to yields
        b. Relationship to quality
    3. Growing conditions
        a. Relationship to yields
        b. Relationship to quality
        c. Weather in relation to curing
    4. Species of forage grown
    5. Diseases and insects
    6. Contaminants
        a. Undesirable plants
        b. Other foreign materials
    7. Storing and curing
E. Field cured hay
    1. Mowing
    2. Wilting and conditioning
    3. Windrowing
    4. Baling
    5. Hauling and stacking
    6. Costs
F. Mow cured hays
    1. Types of mow cured hays
        a. Long hay
        b. Chopped hay
        c. Baled hay
    2. Advantages of mow curing
        a. Mechanical handling
        b. Reduction of nutrient loss
        c. Maximum utilization of storage capacity

3. Barn mow installation
   a. Basic requirements
   b. Building the main duct
   c. Fan installation
   d. Auxiliary heat
   e. Cost of installation
4. Mow curing hay
   a. Moisture content of forage
   b. Filling the mow
   c. Air circulation
   d. Use of auxiliary heat
5. Costs of mow curing

G. Cubes, wafers, and pellets
   1. Advantages of wafering
      a. Handling and storage
      b. Retention of nutrients
   2. Feeding values of wafers
   3. Considerations in wafering
      a. Moisture content of raw material
      b. Windrow preparation
      c. Mechanics of wafering
      d. Storage of the product
      e. Handling equipment
      f. Costs of wafering

X. Silage
   A. Advantages of silage
      1. Conservation of nutrients
      2. Emergency feed
      3. Utilization of crop by-products
   B. Silage curing
      1. Respiration
      2. Enzyme activity
      3. Mold, yeast, and bacterial activity
      4. Anaerobic bacterial action
      5. Importance of low pH
   C. Factors affecting silage making
      1. Moisture content
         a. Forage too moist
         b. Forage too dry
      2. Length of chop
      3. Exposure to air
      4. Additives
         a. Carbohydrates
         b. Inorganic acids
         c. Urea
   d. Crops used for silage and problems related to them (stage of maturity, quality of silage, and special problems)
      1. Corn
      2. Sorghums
      3. Grass silage
      4. Sunflower
      5. Potatoes
      6. Sugarbeet pulp and tops
      7. Pea and bean vines
   E. Silos
      1. Type
         a. Upright
         b. Trench
         c. Stack
         d. Bunker
         e. Pit
      2. Construction
         a. Preventing seepage
         b. Protecting from air
      3. Size and capacity of silos
   F. American Dairy Science Association standards for judging silage
      1. Very good
      2. Good
      3. Fair
      4. Poor
   G. Losses occurring during ensiling
      1. Dry matter losses
      2. Protein losses
      3. Carbohydrate losses
      4. Carotene losses
      5. Spoilage losses
   H. Making silage
      1. Harvesting at proper maturity
      2. Wilting
      3. Chopping
      4. Filling the silo
         a. Distribution of green material
         b. Packing
         c. Adding preservative
         d. Settling
      5. Capping and sealing
   I. Silage quality
      1. Quality of raw material
      2. Type of forage used
      3. Effect of storage facilities
         a. Exclusion of air
         b. Seepage
   J. Methods of making silage
      1. Direct cut silage
         a. Use of preservatives to lower pH
         b. Use of preservatives to lower moisture
      2. Wilted silage
      3. Haylage

Suggested Laboratory Projects (48 hours)

4. Plant a variety of forage plots (3 hours)
2. Compare the botanical characteristics of grasses and legumes. (3 hours)
3. Study grass morphology. (3 hours)
4. Identify the grasses. (3 hours)
5. Identify the legume genera. (3 hours)
6. Identify the true clovers. (3 hours)
7. Identify the medicago species and sweetclovers. (3 hours)
8. Identify the vetches, field peas, soybeans, and lespedeza. (3 hours)
9. Grade hay. (3 hours)
10. Study pasture management practices. (9 hours)
11. Judge silage quality. (3 hours)
12. Study haymaking procedures. (3 hours)
13. Identify poisonous plants. (3 hours)
14. Test the quality of alfalfa hay. (3 hours)

Texts and References

DELORIT *and* AHLGREN, *Crop Production*
HUGHES *and* others, *Forages*
LEONARD *and* REEVES, *General Field Crops Laboratory Manual*
MARTIN *and* LEONARD, *Principles of Field Crop Production*

Fruit Processing

Hours Required

Class, 2; Laboratory, 3.

Course Description

An elementary course in the techniques of fruit processing and how these relate to the selection of the raw material used and the quality of product obtained. Laboratory periods will be devoted to testing and evaluating fresh and processed fruits.

The importance of varietal selection, environment, cultural practices, harvesting, transporting and storing fruit for processing will be emphasized. Particular attention will be given to those handling, processing and storing techniques that may be done at the farm level. Sanitation from field harvest through processing will be stressed.

Laboratory periods will introduce students to the problems related to the deterioration of the quality of fresh and processed fruits. Students will be able to gain actual experience in grading, identifying filth and contamination, and measuring the quality of both fresh and processed fruit. Also students will utilize equipment and techniques commonly used by the processor in quality control work.

Figure 15.—Fruit crop processing involves many factors. These grapes are dried for 2 weeks or longer in the sun to make raisins. The farmers pick the grapes in accordance with weather bureau raisin drying forecasts.

Figure 16.—Scientific testing of moisture in agricultural products is important for many crops. Here a student learns one method or principle in the laboratory.

Major Divisions

		Class hours
I.	Importance and Utilization of Processed Fruit	2
II.	Processing Procedures	6
III.	Micro-organisms in Relation to Fruit Processing	4
IV.	Sanitation in Processing	4
V.	Storage of Fresh Fruit	2
VI.	Fresh Fruit Quality	3
VII.	Fruit Processing Equipment	2
VIII.	Container and Packaging	2
IX.	Grading and Quality Measurement	5
X.	Legal Aspects of Fruit Processing	2
	Total	32

Units of Instruction

- I. Importance and Utilization of Processed Fruit
  - A. Role of on-the-farm processing
    - 1. Importance
      - a. Labor utilization
      - b. Flexibility of operation
      - c. Increased returns
    - 2. Trends
  - B. Geographic distribution
    - 1. Commercial processing plants
    - 2. Farm processing plants
  - C. Production factors affecting processed fruit
    - 1. Labor
    - 2. Mechanization
    - 3. Costs of production
    - 4. Urbanization
  - D. Utilization of processed fruit
    - 1. Fresh
    - 2. Canned
    - 3. Dehydrated
    - 4. Frozen
    - 5. Juice
    - 6. Pickled
    - 7. Fermented
    - 8. Concentrated
  - E. Factors determining the use to be made of fruit
    - 1. Production area
      - a. Transportation
      - b. Storage facilities
      - c. Climatic conditions
      - d. Market outlets
    - 2. Yield
    - 3. Quality
    - 4. Price
    - 5. Consumer preferences

- II. Processing Procedures
  - a. Principles of fruit preservation
    - 1. Asepsis
    - 2. Low temperatures
    - 3. Pasteurization
    - 4. Exclusion of air
    - 5. Sterilization
    - 6. Preservation by antiseptics and other additives
    - 7. Drying
    - 8. Fermentation
    - 9. Radiation
  - B. Preparing the raw material for processing
    - 1. Washing
      - a. Soaking
      - b. Agitation
      - c. Spraying
    - 2. Scalding and blanching
      - a. Temperature
      - b. Time
    - 3. Peeling, cutting, and pitting
      - a. Hand peeling
      - b. Use of heat in peeling
      - c. Mechanical peeling
      - d. Lye solutions used for peeling
      - e. Cutting and pitting
    - 4. Sorting fruits
      - a. Weight separations
      - b. Size separations
      - c. Color separations
      - d. Separating by specific gravity
  - C. Processing methods
    - 1. Canning
      - a. Sirups used in canning
      - b. Brine solutions used in canning
      - c. Filling the cans
      - d. Siruping
      - e. Exhausting
      - f. Sealing
      - g. Sterilizing
      - h. Cooling
    - 2. Bottling and canning fruit juices
      - a. Extraction of juice
      - b. Pasteurization
      - c. Other methods of preservation

    - d. Filtration
    - e. Clarification
  - 3. By-products of the canning industry
- d. Freezing fruits and fruit products
  - 1. Principles involved in freezing
  - 2. Controlling microbiological spoilage
  - 3. Controlling enzyme activity
    - a. Maturity
    - b. Exclusion of oxygen
    - c. Addition of sugar or sirup
    - d. Addition of acids
    - e. Use of antioxidants or reducing agents
  - 4. Nonenzymatic chemical changes
  - 5. Physical changes during freezing and thawing
    - a. Volume
    - b. Weight
    - c. Texture
  - 6. Heat transfer determinants
    - a. Type of fruit
    - b. Sugar content of fruit and sirup
    - c. Container
  - 7. Storage conditions
  - 8. Frozen fruit products
- E. Sun-drying and dehydration
  - 1. Farm use of this method
  - 2. Washing trays and boxes
  - 3. Drying yard requirements
    - a. Size
    - b. Sanitation requirements
    - c. Physical arrangement
  - 4. Cutting and dipping shed
  - 5. Harvesting and preparing the fruit
  - 6. Sulfuring
  - 7. Spreading and drying
    - a. Spreading
    - b. Stacking
    - c. Turning
    - d. Removal from trays
  - 8. Treating rain damaged fruit
  - 9. Sorting and boxing
  - 10. Yields
- F. Dehydration
  - 1. Types of dehydraters
    - a. Natural draft
    - b. Distillation
    - c. Vacuum
    - d. Forced draft
    - e. Freeze drying
  - 2. Condition of dehydration chamber
    - a. Air circulation
    - b. Relative humidity
  - 3. Procedures
    - a. Sorting
    - b. Trimming
    - c. Dipping
    - d. Sulfuring
    - e. Drying temperature
    - f. Drying time
    - g. Turning the fruit
    - h. Yield
- G. Use of additives
  - 1. Definition
  - 2. Labeling
  - 3. Amounts
  - 4. Use
    - a. Antioxidants
    - b. Antibrowning
    - c. Firming
    - d. Waxing
  - 5. Other chemical additives
    - a. Artificial flavoring
    - b. Artificial coloring
    - c. Flavor intensifiers
    - d. Buffers
    - e. Neutralizing agents
    - f. Stabilizers
    - g. Emulsifiers
- H. Farm packing shed
  - 1. Farm packaged fruits
  - 2. Types of operations
  - 3. Facilities
    - a. Receiving
    - b. Sanitizing and waxing
    - c. Grading
    - d. Packing
    - e. Storing
    - f. Auxiliary

II. Micro-organisms in Relation to Fruit Processing
- A. Introduction to microbes
- B. Kinds of microbiological life
  - 1. Protozoa
  - 2. Bacteria
  - 3. Molds
  - 4. Yeasts
  - 5. Rickettsia
  - 6. Virus
- C. Importance

1. Beneficial aspects
   a. Food and beverage uses
      (1) Alcohol fermentation
      (2) Acid fermentation
   b. Industrial uses
   c. Medical and scientific uses
2. Detrimental aspects
   a. Diseases of fruits
   b. Food spoilage

D. Micro-organisms important to fruit processing
   1. Bacteria
      a. Morphology
      b. Growth and development
      c. Reproduction
      d. Gross morphology
      e. Production of chemical substances
      f. Beneficial aspects of bacteria
      g. Detrimental aspects of bacteria
   2. Yeasts
      a. Morphology
      b. Growth and development
      c. Reproduction
      d. Gross morphology
      e. Production of chemical substances
      f. Beneficial aspects
      g. Detrimental aspects
   3. Molds
      a. Morphology
      b. Growth and development
      c. Reproduction
      d. Gross morphology
      e. Production of chemical substances
      f. Beneficial aspects
      g. Detrimental aspects

E. Effect of environment on micro-organisms
   1. Physical
      a. Temperature
      b. Moisture
      c. Osmotic changes
      d. Light
      e. Radiation
   2. Chemical
      a. pH
      b. Germicides

F. Prevention and control
   1. Methods
      a. Destroy
      b. Remove
      c. Inhibit
   2. Determining contamination
      a. Kind
      b. Number
   3. Cleanliness
      a. Smooth resistant surfaces
      b. Removal of media
      c. Establishing an undersirable environment
   4. Inhibiting tools
      a. Refrigeration
      b. Dryness
      c. Exclusion of air
      d. Chemicals
   5. Tools for destruction
      a. Dry heat
      b. Steam and hot water
      c. Chemicals
      d. Ionizing radiations
      e. Ozone

G. Encouraging favorable micro-organisms
   1. Proper media
   2. Optimum temperature
   3. Proper pH
   4. Proper chemical environment
   5. Inhibit enemies

IV. Sanitation in Processing

A. Necessity
   1. Legal requirements
   2. Moral obligation
   3. Reduction of losses

B. Plant location
   1. Water supply
   2. Solid waste disposal
   3. Liquid waste disposal
   4. Area free of dust

C. Plant layout
   1. Easy cleaning
   2. Streamlined flow of product
   3. Sloped floors
   4. Adequate drains
   5. Sufficient space around machines
   6. Adequate lighting
   7. Proper screening of building

D. Rodent control
   1. Troublesome species
      a. Rats
      b. Mice
   2. Evidence of infestation
   3. Types of damage
   4. Prevention of infestation

        - a. Elimination of harborages
        - b. Elimination of points of ingress
    - 5. Controls
        - a. Trapping
        - b. Poisoning
        - c. Fumigation
- e. Insect control
    - 1. Troublesome species
        - a. Flies
        - b. Cockroaches
        - c. Crickets
        - d. Ants
        - e. Wasps and bees
    - 2. Types of damage by insects
    - 3. Insect control measures
        - a. Removal of breeding media
        - b. Removal of feeding material
        - c. General sanitation
        - d. Screening
        - e. Use of insecticides
- f. Micro-organisms: physical control
    - 1. Cleaning
        - a. Cleaning crews
        - b. Cleanup procedures
    - 2. Form of equipment
        - a. Rounded openings
        - b. Smooth surfaces
        - c. Noncorroding material
    - 3. Sterilizing equipment
- G. Micro-organisms: chemical control
    - 1. Destruction of microbe by disinfectants
        - a. Oxidation
        - b. Reduction
        - c. Protein coagulation
        - d. Plasmolysis
        - e. Depression of surface tension
    - 2. Factors affecting germicidal action
        - a. Nature of the germicide
        - b. Concentration
        - c. Rate of application
        - d. Temperature
        - e. Presence of foreign materials
    - 3. Types of disinfectants
        - a. Metallic salts
        - b. Chlorine and similar compounds
        - c. Phenols
        - d. Fumigants
        - e. Antibiotic agents
        - f. Other organic substances
    - 4. Phenol coefficients
- H. General considerations
    - 1. Uniforms
    - 2. First aid supplies
    - 3. Rest room facilities
    - 4. Drinking fountains
    - 5. Ventilation
    - 6. Sanitation rules and regulations for workers
- I. Disposal of wastes
    - 1. Classes of pollution
        - a. Contamination
        - b. Pollution
        - c. Nuisance
    - 2. Procedures
        - a. Separation of solids from liquids
        - b. Disposal of solids
            - (1) Dehydration
            - (2) Composting
            - (3) Livestock feed
            - (4) Organic manure
            - (5) Cut and fill dumps
        - c. Disposal of liquid waste
            - (1) Sewage systems
            - (2) Lagoons
            - (3) Soil infiltration
- J. Sanitation in fresh fruit handling
    - 1. Picking
        - a. Personnel
        - b. Equipment
        - c. Field containers
    - 2. Field packing
    - 3. Transporting

V. Storage of Fresh Fruit
- A. Biological processes of stored fruit
    - 1. Respiration
        - a. Amount of sugars available
        - b. Number of living cells
        - c. Water contents of tissue
        - d. Temperature
        - e. Oxygen—carbon dioxide level
        - f. Liberation of heat
        - g. Relative humidity
        - h. Age of fruit
    - 2. Transpiration
        - a. Water content of tissue
        - b. Outer cover of fruit
        - c. Temperature
        - d. Relative humidity
    - 3. Enzyme activity
        - a. After ripening

        - b. Cellular breakdown
- B. Temperature control of storage facility
    - 1. Nonrefrigerated
        - a. Temperature
        - b. Humidity control
        - c. Air exchange
    - 2. Refrigerated
        - a. Temperature
        - b. Humidity control
    - 3. Freezers
        - a. Mechanics of freezing
        - b. Freezing agents
        - c. Temperature controls
        - d. Humidity control
        - e. Defrosting
- C. Precooling practices
    - 1. Value
    - 2. Methods used
- D. Fruit treatment
    - 1. Ripening agents
    - 2. Coloring agents
    - 3. Applying spoilage inhibitors
    - 4. Waxing
- E. Effects of storage on quality
    - 1. Wilting
    - 2. Flavor and odor
    - 3. Loss of color
    - 4. Freezing and cold storage injury
    - 5. Diseases
    - 6. Molds and rot
    - 7. After ripening
- F. On-the-farm storage
    - 1. Types of farm storage
        - a. Long term storage
        - b. Temporary storage
    - 2. Facilities
        - a. Construction requirements
        - b. Operation and maintenance
    - 3. Costs
        - a. Costs of operating storage facilities
        - b. Shrinkage losses

VI. Fresh Fruit Quality
- A. Production
    - 1. Climate
    - 2. Soil
    - 3. Varietal adaptation
    - 4. Cultural operations
        - a. Irrigation
        - b. Fertilization
        - c. Thinning
        - d. Pruning
        - e. Frost protection
        - f. Pest control
- B. Effect of harvest and post harvest operations
    - 1. Harvest
        - a. Picking procedures
        - b. Fill of containers
    - 2. Transporting
        - a. Refrigerated transporation
        - b. Nonrefrigerated transportation
- C. Selection of fruit for processing
    - 1. Variety
        - a. Product produced
        - b. Yield
    - 2. Maturity
        - a. Uniformity
        - b. Sugar-acid ratio
        - c. Color
        - d. Size
        - e. Shape
    - 3. Condition of fruit
        - a. Insect damage
        - b. Disease
        - c. Rodent and bird damage
        - d. Mechanical damage
        - e. Frost damage
    - 4. Economic factors affecting selection
        - a. Market outlet
        - b. Demand
        - c. Supply
        - d. Cost of processing
- D. Reasons for deterioration of quality
    - 1. Natural aging
    - 2. Improper handling
    - 3. Improper storage environment
        - a. Macroenvironment
        - b. Microenvironment
    - 4. Incorrect stage of maturity
        - a. Lack of uniformity
        - b. Lack of maturity
        - c. Too ripe
    - 5. Contamination
        - a. Birds and animals
        - b. Micro-organisms
        - c. Inert materials

VII. Fruit Processing Equipment
- A. Physical and chemical principles involved
    - 1. Solutions
    - 2. Specific gravity

    3. Heat transfer
    4. Evaporation
    5. Air movement
- B. Fruit characteristics affecting equipment
    1. Size
    2. Shape
    3. Weight
    4. Condition
        a. Maturity
        b. Spray residue
        c. Fruit damage
- C. Types of equipment used
    1. Scales
        a. Selection of unit
        b. Location
        c. Ease of maintenance
    2. Conveyors
        a. Types
        b. Use
    3. Dumps
        a. Types
        b. Other unloading methods
    4. Washers
        a. Methods
        b. Water supply
        c. Agents used
        d. Temperatures
    5. Bleaching equipment
        a. Agents used
        b. Bleaching containers
        c. Operation procedures
    6. Dehydrators
        a. Principles involved
        b. Methods of removing moisture
        c. Source of heat
        d. Temperature control
    7. Separators
        a. Types
        b. Selection
    8. Grading machinery
        a. Methods
        b. Relation to subsequent operations
    9. Waxing equipment
        a. Materials used
        b. Methods of applying
    10. Fans
        a. Principles of air movement
        b. Amount of air to be moved
        c. Speeds
        d. Adjustments
    11. Packaging equipment
        a. Relation to product
        b. Containers suitable
        c. Subsequent handling
    12 Storage equipment
        a. Principles
        b. Selection of equipment
        c. Materials handling
    13. Pasteurizers
        a. Purpose of pasteurization
        b. Methods
    14. Boilers
        a. Requirements
        b. Types
- D. Sequence of operations
    1. Smooth flow of product
    2. Relation to quality of end product
    3. Effect on total cost of operations
- E. Field processing equipment
    1. Trends
    2. Types
    3. Construction and design

VIII. Containers and Packaging
- A. Importance
    1. Merchandizing
    2. Sanitation
    3. Efficiency on transporation and distribution
- B. Containers
    1. Definitions
    2. Description of material and packages
        a. Metal cans
        b. Glass containers
        c. Folding boxes
        d. Waxed paper packages
        e. Plastic wraps and packages
        f. Corrugated shipping containers
        g. Wood shipping containers
        h. Bulk shipping containers
- C. Warehousing and shipping operations
    1. Storage
        a. Cool
        b. Cold
        c. Dry
        d. Warm
    2. Handling
        a. Bulk
        b. Boxes
        c. Tanks
        d. Fork-lifts

- e. Belts
- f. Pipes and tubes
- 3. Marketing functions of packages
  - a. Sanitation
  - b. Advertising
  - c. Legal requirements
    - (1) Size
    - (2) Fill and weight
    - (3) Labeling
- 4. Filling and sealing
  - a. Legal requirements
  - b. Equipment design and operation
- 5. Quality control
  - a. Checking fills
  - b. Checking seals
  - c. Checking package conditions
  - d. Inspection of package decorations
- D. Field containers
  - 1. Harvesting
    - a. Picking bags
    - b. Boxes, flats, baskets, etc.
  - 2. Transport containers

- IX. Grading and Quality Measurement
  - A. Grading
    - 1. Purpose of grading
    - 2. Types of grading
      - a. Shipping point
      - b. Inspection of raw products to be processed
  - B. Grading fresh fruit
    - 1. Sampling
      - a. Characteristics of the sample
      - b. Sampling procedures
    - 2. Factors in grading fresh fruit
      - a. Maturity
      - b. Size
      - c. Shape
      - d. Color
      - e. Injury
      - f. Damage
      - g. Cleanliness
    - 3. U.S. Department of Agriculture grades
      - a. U.S. Extra No. 1 grades
      - b. U.S. No. 1
      - c. U.S. No. 2
      - d. Unclassified
    - 4. Tolerances
    - 5. Inspection certificates
  - C. Grading processed fruit
    - 1. Sampling
    - 2. Factors
      - a. Size
      - b. Color
      - c. Uniformity
      - d. Freedom from filth and contamination
      - e. Uniformity
      - f. Defects
      - g. Sirup
    - 3. Sizes and types of containers
    - 4. Net weight
    - 5. Vacuum
    - 6. Brix measurement
    - 7. Container condition
    - 8. Degree of fill
    - 9. U.S. Department of Agriculture grades
      - a. Grade A
      - b. Grade B
      - c. Grade C
      - d. Sstd
    - 10. Degree of fill
  - D. Measuring the quality of processed fruits
    - 1. Degree of filth and contamination
      - a. Rodent and bird filth
      - b. Insect fragments
      - c. Rot and mold
      - d. Extraneous material
    - 2. Amount of defects and damage
    - 3. Bacterial counts
    - 4. Uniformity of the processed product
    - 5. Degree of maturity of raw product
    - 6. Odor and flavor
    - 7. Moisture content
    - 8. Color
    - 9. Soluble solids
    - 10. Specific gravity of sirups and brines
    - 11. Chemical analysis of processed product

- X. Legal Aspects of Fruit Processing
  - A. Laws
    - 1. Federal Food, Drug and Cosmetic Act
    - 2. Miller Pesticide Amendments of 1954
    - 3. Food Additives Act of 1958
    - 4. Color Additives Act of 1960
    - 5. Public Health Service Act of 1944
    - 6. State laws
      - a. Cannery operation
        - (1) Public health requirements
        - (2) Dry yard operation
    - 7. County ordinances
      - a. Zoning

b. Health standards for workers
8. City ordinances
a. Zoning
b. Waste disposal
c. Health requirements
B. Regulatory agencies
1. Food and Drug Administration
2. U.S. Public Health Service
3. U.S. Department of Agriculture
4. State agencies
5. County and municipal agencies
C. Sources of information
1. Local
2. State
3. National

Recommended Laboratory Projects
(48 hours)

1. Study the morphological characteristics of micro-organisms. (3 hours)
2. Study the beneficial micro-organisms important in fruit processing. (3 hours)
3. Study the detrimental micro-organisms in fruit processing. (3 hours)
4. Determine micro-organism contamination of processed fruit. (3 hours)
5. Determine the insect filth and contamination in processed fruit. (3 hours)
6. Determine the rodent and extraneous material contamination in processed fruit. (3 hours)
7. Study the effect of storage on fresh and processed fruit quality. (6 hours)
8. Determine the sugar content of fruit juices by the refractive index method. (3 hours)
9. Determine the specific gravity of fruit juices, sirups, and brines. (3 hours)
10. Determine the moisture content of processed fruit. (3 hours)
11. Determine the color index of fruit and fruit products by using reflectance, transmittance, and spinning disk colorimeters. (3 hours)
12. Grade canned, dehydrated and frozen fruit. (6 hours)
13. Study farm processing and storage facilities. (3 hours)
14. Visit the quality control laboratory of a cannery. (3 hours)

Texts and References

ANDERSON, *Sanitation for the Food Preservation Industry*
COPLEY *and* VAN ARSDALE, *Food Dehydration*
CRUESS, *Commercial Fruit and Vegetable Products*
FARRALL, *Engineering for Dairy and Food Products*
HALL, *Processing Equipment for Agricultural Products*
MEYER, *Food Chemistry*
TRESSLER *and* JOSLYN, *Fruit and Vegetable Juice Processing*
Technology
U.S. Department of Health, Education, and Welfare, *Food Processing Technology, A Suggested 2-Year Post High School Curriculum*
VAN ARSDEL, *Food Dehydration, Vol. I.*
WOOLRICH, *Handbook of Refrigeration Engineering*

Grassland Management

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of the conditions affecting grasslands and the manipulation of those factors which will enhance soil conservation and livestock grazing capacity. Laboratory periods include identifying the grassland species, charting, mapping, inventorying the range and evaluating vegetation.

This course is designed to impart a working knowledge of the principles of ecology as applied to the forage production of grazing lands. Special emphasis will be placed upon the role of soil and water conservation, grazing, and the response of both plants and animals to environmental conditions. Particular attention is given to study of the development of grasslands to their fullest potential.

During the laboratory period the student will have an opportunity to learn the techniques of studying plant communities and evaluating range conditions. Also the student will make field visits to gain actual experience in mapping, charting vegetation, and controlling undersirable species of plants.

Major Divisions

	Class hours
I. Distribution and Classification of Grasslands	2
II. Environmental Relationships	4

III.	Ecosystems and Grassland Management	2
IV.	Soil and Water Conservation of Grasslands	4
V.	Grazing Grasslands	4
VI.	Nutrition in Relation to Grazing	4
VII.	Poisonous Plants	4
VIII.	Cultural Aspects of Grassland Management	4
IX.	Evaluating Range Condition	4
	Total	32

Units of Instruction

I. Distribution and Classification of Grasslands
  A. Principles of plant distribution
    1. Climatic factors
    2. Physiographic factors
    3. Edaphic factors
    4. Biotic factors
    5. Tolerance theory
  B. Factor replaceability in plant distribution
    1. Elevation substituted for latitude
    2. Slope angle and direction for latitude
    3. Parent material compensates for climate
    4. Rainfall replaced by fog and dew
    5. Soil texture for moisture
  C. Vegetation regions and their characteristics
    1. Tall grass
    2. Short grass
    3. Desert grass
    4. Bunch grass
    5. Northern and intermountain shrub
    6. Southern desert shrub
    7. Chaparral
    8. Pinon-Juniper
    9. Coniferous forest
  D. Land uses in the United States
    1. Land used for grazing
    2. Land used for farm production
    3. Ownership of grazing lands in the United States
    4. Grazing lands and livestock production

II. Environmental Relationships
  A. Light and plant communities
    1. Amount of light
      a. Interval
      b. Intensity
      c. Light variations
    2. Shade tolerance
    3. Plant adaptation and light requirement
    4. Effect on size, shape, and orientation of plant parts
    5. Effect on stomatal movement
  B. Temperature and plant communities
    1. Temperature and plant response
      a. Germination
      b. Absorption of water
      c. Evaporative loss of water
      d. Photosynthesis
      e. Threshold value and thermal unit response
      f. Translocation and storage of sugar
    2. Effect of plant populations on atmospheric temperatures
    3. Temperature in relation to distribution of plants
  C. Atmosphere and plant communities
    1. Atmospheric moisture
      a. Humidity
      b. Dew
      c. Fog
    2. Effect of humidity on transpiration and evaporation
    3. Air movements
      a. Relationships to temperature
      b. As a transport for seeds
      c. Role in pollination
      d. Effect on soil
      e. Prevailing winds and air pockets
  D. Soil and plant communities
    1. Soil pH
    2. Soil fertility
    3. Soil texture
    4. Soil profile
    5. Soil-water relationships
    6. Soil color as influencing absorption of heat
  E. Plant populations as modifiers of microenvironment
    1. Temperature
    2. Canopy effect
    3. Wind movements and velocities
    4. Mulch
      a. Effect on heaving
      b. Lowering of evaporation and dessication losses
  F. Influencing the microenvironment
    1. Cutting trees

    2. Planting shelter belts
    3. Soil conservation
    4. Irrigation
    5. Fertilization
  G. Problems in grasslands related to climatic environment
    1. Variability of water supply
    2. Maintenance of forage species
    3. Soil erosion

III. Ecosystems and Grasslands Management
  A. Types of components in ecosystems
    1. Autotrophic components
    2. Heterotrophic components
  B. Components of ecosystems
    1. Abiotic substances
    2. Producer organisms
    3. Decomposer organisms
  C. Nitrogen cycle
  D. Carbon cycle
  E. Biotic relationships in grasslands communities
    1. Competition of species
      a. Parasites
      b. Epiphytes
      c. Symbiosis
    2. Stratification of species
      a. Dominant species
      b. Subordinate species
    3. Dependence
  F. Animals as biotic factors
    1. Soil microfauna
    2. Insects
    3. Small herbivores
    4. Large herbivores
    5. Predators
    6. Man

IV. Soil and Water Conservation of Grasslands
  A. Hydrological cycle
    1. Evaporation
    2. Transpiration
    3. Condensation
    4. Precipitation
  B. Factors affecting evapotranspiration
    1. Atmospheric conditions
    2. Soil conditions
    3. Type of vegetation
    4. Volume of vegetation
    5. Land management
  C. Factors affecting infiltration of water
    1. Soil texture
    2. Soil structure
    3. Soil moisture content
    4. Duration of application
  D. Causes of erosion
    1. Geologic erosion
    2. Accelerated erosion
      a. Water
      b. Wind
  E. Role of grass in soil and water conservation
    1. Complementary benefits between plants
    2. Benefits derived from grasses
      a. Canopy interception
      b. Loosening of soil
      c. Sod forming
      d. Provider of humus
      e. Soil building
      f. Decreases velocity of surface runoff
      g. Decreases amount of sedimentation in streams
  F. Types of plants and their relationships to water conservation
    1. Hydrophytes
    2. Mesophytes
    3. Xerophytes
  G. Control of erosion
    1. Grassland farming
    2. Grassed waterways
    3. Catch basins
      a. Runoff control
      b. Dispersement of cattle
    4. Importance of dense ground cover

V. Grazing Grasslands
  A. Plant succession and grazing
    1. Concept of plant succession
      a. Constant change
      b. Similar habitats support similar communities
      c. Contrasting habitats result in different sequence
      d. Changes follow a definite pattern
    2. Causes of plant succession
      a. Physiogramic changes modify environment
      b. Community changes result in environmental changes
    3. Climax communities
      a. Priseres
      b. Subseres

- B. Effect of grazing on plant communities
  - 1. Progressive succession
  - 2. Retrogressive succession
    - a. Physiological disturbance of climax plants
    - b. Composition changes
    - c. Invasion of new species
    - d. Disappearance of climax plants
- C. Plant physiology in relation to grazing
  - 1. Effect of foliar removal on plants
    - a. Food synthesis
    - b. Root reserves
    - c. Seed production
  - 2. Nutrient composition of plants
- D. Grazing and soil conservation
  - 1. Soil compaction
  - 2. Soil humus
  - 3. Amount of cover
    - a. Soil coverage
    - b. Weight of total cover
    - c. Forage density
    - d. Average height
    - e. Effective weight index
- E. Practical considerations in grazing
  - 1. Utilization of forage as affected by preference
    - a. Selectivity of animals
    - b. Type of plants
    - c. Stage of growth
    - d. Growing conditions
  - 2. Season of grazing
    - a. Condition of plant
    - b. Trampling of plants and soil
    - c. Spring and fall deferred grazing
    - d. Growing conditions
  - 3. Duration of grazing period
    - a. Type of plants
    - b. Density of plant population
    - c. Rotation grazing
  - 4. Grazing habits of animals
    - a. Terrain
    - b. Closeness of grazing
  - 5. Seasonal migrations of animals
- F. Facilitating or enabling practices
  - 1. Water supply
  - 2. Mineral supply
  - 3. Protection of new seedlings
  - 4. Supplemental feeding

VI. Nutrition in Relation to Grazing

- A. Nutritional requirements of livestock
  - 1. Cattle
    - a. Maintenance
    - b. Growth and fattening
    - c. Reproduction
  - 2. Sheep
    - a. Maintenance
    - b. Growth and fattening
    - c. Wool production
    - d. Reproduction
- B. Nutritional value of forage
  - 1. Season and forage value
    - a. Change in nutrient composition
    - b. Changes in leaf-stem ratio
    - c. Changes in range composition
  - 2. Nutrient composition and stage of growth
    - a. Early leaf stage
    - b. Just before flowering
    - c. Full bloom
    - d. Seeds in dough stage
    - e. Plants mature—seeds cast
    - f. Herbage dry and weathered
  - 3. Type of plant and forage value
    - a. Legumes
    - b. Grasses
    - c. Forbs
    - d. Browse plants
  - 4. Climate and forage value
    - a. Amount and distribution
    - b. Temperature
    - c. Length of growing season
  - 5. Soils and forage value
    - a. Mineral composition
    - b. Protein content
  - 6. Digestibility
    - a. Immature v. mature plants
    - b. Effect of season
    - c. Mixed range v. pure stand of grass
    - d. Crude fiber and lignin
    - e. Degree of grazing
  - 7. Leaching of nutrients
    - a. Nitrogen-free-extract
    - b. Protein
    - c. Calcium and phosphorous
    - d. Effect on palatability
    - e. Effect of late rains
  - 8. Factors affecting losses of energy in digestion
    - a. Level of intake
    - b. Nutrient balance

9. Deficiencies likely to occur in forages
   a. Protein
   b. Minerals
   c. Energy
   d. Vitamin A

VII. Poisonous Plants
 A. Importance of poisonous plants
   1. Occurrence of toxic plants
   2. Difficulties in defining the poisoning problem
   3. Economic losses from toxic plants
 B. Poisoning properties of plants
   1. Chemical properties of toxic plants
     a. Alkaloids
     b. Glucosides
     c. Resinoids
     d. Phytotoxins
     e. Oxalic acid
     f. Other compounds
   2. Plants causing mechanical injury
   3. Physiological action of toxins
     a. Blood poisons
     b. Neurotoxins
     c. Neuromuscular toxins
     d. Muscular toxins
     e. Irritants
   4. Special poisoning problems
     a. Nitrate poisoning
     b. Selenium poisoning
     c. Molybdenum poisoning
     d. Fluorine poisoning
     e. Grass tetany
     f. Phlaris staggers
 C. Contributory causes in poisoning
   1. Season
     a. Lack of good forage
     b. Variation in toxic properties with progressive plant changes
     c. Delayed effect in poisoning
     d. Weather and poisoning problems
   2. Variation in susceptibility of animals to toxins
   3. Grazing hazards
     a. Availability of toxic plants
     b. Scarcity of good forage
     c. Undersalting
     d. Plants that attract livestock
     e. Trailing through poisonous plants
     f. Saline water
   4. Forage poisoning problems
     a. Toxic plants mixed in forages
     b. Moldy feed
     c. Spoiled sweetclover
     d. Ergot poisoning
     e. Cornstalk disease
     f. Algae
 D. Preventing plant poisoning problems
   1. Proper grazing
     a. Timing the grazing period
     b. Proper degree of grazing
     c. Proper type of livestock
   2. Distributing livestock over the range
   3. Adequate supplies of minerals
   4. Supplemental feeding
   5. Controlling poisonous plants
   6. Isolating infested areas
 E. Important livestock poisoning species
   1. Pingue
   2. Burroweed and jimmyweed
   3. Locos and poisonvetches
   4. Waterhemlock
   5. Larkspurs
   6. Sneezeweeds
   7. Lupines
   8. Crazyweeds
   9. Podgrasses and arrowgrasses
   10. Deathcamases

VIII. Cultural aspects of Grassland Management
 A. Mechanical removal of sagebrush
   1. Repeated cutting or defoliation
     a. Heavy duty mowers
     b. Heavy duty brush saws
     c. Cutting followed by grazing
   2. Digging or grubbing
   3. Cabling, chaining, and railing
   4. Brush beaters
   5. Brushland plows
   6. Girdling
 B. Chemical control of sagebrush
   1. Foliage sprays
     a. Application equipment
     b. Methods of applying
     c. Timing applications
   2. Bark treatments
     a. Broadcast bark treatment
     b. Basal bark treatment
   3. Trunk wounds
     a. Frill treatment
     b. Notching

        - c. Cut-over stumps
    - 4. Root applications
        - a. Methods of treating
        - b. Timing for effective kill
    - 5. Specific chemicals for brush control
        - a. 2, 4D
        - b. 2, 4, 5T
        - c. Silvex
        - d. Amino Triazole
        - e. Ammonium Sulfamate
        - f. Tordon
    - 6. Special problems in chemical brush control
        - a. Followup treatments
        - b. Erosion in control areas
        - c. Annual forbs and grasses
        - d. Costs
- C. Burning as a method of sagebrush control
    - 1. Burning as a factor of succession
    - 2. Factors favoring burning as a control measure
        - a. Dense sagebrush
        - b. Terrain and vegetation favoring containment
        - c. Fire resistant grasses
        - d. Range used principally by livestock
        - e. Burn not favorable to undesired species
        - f. Burn not conducive to erosion
    - 3. Burning procedures
        - a. Determining when to burn
        - b. Preparing the area for burning
        - c. Center firing
        - d. Strip firing
        - e. Edge burning
    - 4. Safety in sagebrush burning
    - 5. Federal, State, and county fire laws
    - 6. Management after burning
        - a. Spot treatments
        - b. Deferred grazing
        - c. Eradication of fire resistant plants
- D. Seeding rangelands
    - 1. Selecting the proper species
        - a. Introduced species
        - b. Ecotypes
    - 2. Methods of planting
        - a. Broadcasting
        - b. Airplane broadcasting
        - c. Heavy duty range drills
        - d. Grassland seeders
    - 3. Seeding
        - a. Factors influencing depth
        - b. Avoiding plant competition
        - c. Timing for favorable conditions
        - d. Burned over lands
        - e. Seeding in mulches
    - 4. Mixtures
        - a. Compensation for variations in environment
        - b. Utilization of moisture and nutrients
        - c. Uniform production
        - d. Forage quality
        - e. Complementation between plants
    - 5. Grazing practices
    - 6. Costs of burning
    - 7. Use of fuel breaks on ranges
        - a. Eradication of brush
        - b. Revegetation
- E. Range fertilization
    - 1. Selecting the proper fertilizer
        - a. Effect on yields
        - b. Effect on palatability
        - c. Sustaining the desired species
    - 2. Timing the application
    - 3. Methods of applying
    - 4. Limiting factors

IX. Evaluating Range Condition
- A. Use factor
    - 1. Definition of use factor
    - 2. Variability in the use factor
        - a. Associated species
        - b. Type of livestock
        - c. Season and use factor
        - d. Year
        - e. Past grazing use
        - f. Local conditions
    - 3. Value of the use factor
    - 4. Methods of estimating utilization
        - a. Weight determinations
        - b. Ocular appraisal
        - c. Indicator species
        - d. Indicator areas
- B. Range inventory
    - 1, Quantitative methods of analysis
        - a. Number of individuals
        - b. Weight of vegetative material
        - c. Area occupied
        - d. Species present

2. Qualitative methods of analysis
    a. Sociability
    b. Dispersion
    c. Vitality
    d. Stratification
    e. Periodicity
3. Range condition classification
    a. Excellent condition ranges
    b. Good condition ranges
    c. Fair condition ranges
    d. Poor condition ranges

C. Use of plots
1. Types of quadrats
    a. List quadrat
    b. List-count quadrat
    c. Chart quadrat
2. Distribution of quadrats
    a. Selected sampling
    b. Random sampling
3. Shape of quadrats
4. Size and number of quadrats
5. Transects

D. Use of fenced areas
1. Protected areas
2. Grazed areas
3. Partially protected areas
4. Size and location of areas

E. Mapping range areas
1. Mapping techniques
    a. Photographic maps
    b. Planometric maps
2. Plotting vegetation
3. Inclusion of improvements

Suggested Laboratory Projects (48 hours)

1. Study the morphological characteristics of range grasses. (3 hours)
2. Identify the grass tribes. (3 hours)
3. Identify and evaluate the range grasses. (6 hours)
4. Identify and evaluate the range legumes. (3 hours)
5. Identify and evaluate the browse plants. (3 hours)
6. Identify the poisonous plants of the range. (3 hours)
7. Identify the undersired species on the range. (3 hours)
8. Estimate vegetation on range area. (3 hours)
9. Map and chart vegetation on range area. (6 hours)
10. Inventory wildlife on range area. (3 hours)
11. Classify conditions on range area. (9 hours)
12. Establish brush control plots. (3 hours)

Texts and References

There are few up-to-date books adapted to the specific units of instruction of this class. Therefore, some of the suggested references listed below will be somewhat dated, but the information they contain is still quite usable. Because of the absence of current books on this subject, it is suggested that timely reading assignments be selected from the *Journal of Range Management*. Instructors should search recent publications for pertinent references.

HITCHCOCK, *Manual of the Grasses of the United States*

KINGSBURY, *Poisonous Plants of the United States and Canada*

Plant Diseases and Pests

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the principles involved in controlling plant diseases and pests, primarily insects. The control of certain rodents and larger animals is included in the course. Laboratory work will include work in the identification of pests and setting up pest control programs.

The first 5 weeks of the course are devoted to plant diseases; these include: bacteria, fungi, viruses, and nematodes. This will include study of the casual organism, host plants, symptoms and signs, the life cycle, epiphytotics and their causes, and economic controls for the several organisms considered.

The next 8 weeks include a selected unit covering primarily insects of economic importance to agriculture. This will encompass development and metamorphosis, anatomy, types of mouth parts, and a brief review of classification of the insects in the 10 most important economic orders. This course lends itself to the use of audiovisual aids. Lectures should be supplemented with deomonstrations using specimens and exhibits whenever possible.

In the final unit of 3 weeks, disease and insect controls and animal pests and controls

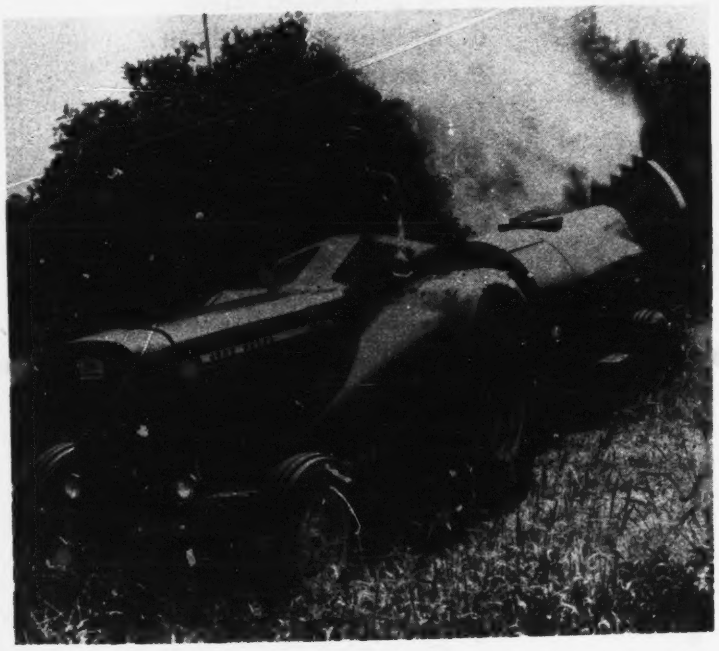

Figure 17.—Scientific selection, application, and timing of the use of pest control materials is vital to the production of fruit crops. Here is a citrus orchard being sprayed.

are considered together with safety rules and laws.

The laboratory sessions develop intensive work on bacteria, fungi, viruses, and nematodes causing plant diseases. Specimens of the diseases are brought in, Riker mounts secured, and prepared microscope slides used for actual observation of the organisms. Several motion pictures and 2- by 2-inch slides are used to make the work more meaningful to the student. Symptoms and signs, life cycles, epiphytology, and economic controls of the basic types listed are studied in considerable detail.

In entomology, much the same plan in followed with work on actual specimens. This includes the dissection of a grasshopper as a typical insect. The mouthparts of various types are observed under the microscope; this is from actual specimens and prepared microscope slides of the grasshopper, beetle, house fly, butterfly, and thrips. This is concluded by study of important specimens of the significant insect orders. An insect collection is made by each student as a part of the course. After due consideration to the proper control of plant diseases and insects, a laboratory session is devoted to the control of larger animal pests, and one period is devoted to safety considerations and legal requirements.

Major Divisions

		Class hours
I.	Plant Diseases Due to Bacteria	2
II.	Plant Diseases Due to Fungi	4
III.	Plant Diseases Due to Viruses	2
IV.	Plant Diseases Due to Nematodes	2
V.	Insects: Development, Metamorphosis, Anatomy, Mouthparts, Orders	6
VI.	Insects: Study of Selected Orders	10
VII.	Disease and Insect Control	2
VIII.	Animal Pests and Control	2
IX.	Safety Precautions, Laws	2
	Total	32

Units of Instruction

I. Plant Diseases Due to Bacteria
  A. Introduction
    1. Bacteriology
    2. Pathology
    3. Control
  B. Bacterial canker of tomatoes
    1. Seed
    2. Symptoms
    3. Control
  C. Crown gall
    1. Symptoms
    2. Etiology and epiphytology
    3. Control
      a. Sanitation
      b. Chemicals
  D. Alfalfa wilt
    1. Vascular disease
    2. Symptoms
    3. Internal structures
    4. Control

II. Plant Diseases Due to Fungi
  A. Introduction
    1. Structure
    2. Nutrition
    3. Infection
    4. Types of parasitism
  B. Stem rust of grains and grasses
    1. Host plants
    2. Symptoms and signs
    3. Life cycle
      a. Grain
      b. Barberry
    4. Outbreaks
  C. Seedling infection smuts

    - 5. Control
    - 1. Bunt of wheat
    - 2. Hosts
    - 3. Symptoms and signs
    - 4. Life cycle
    - 5. Epiphytology
    - 6. Control
  - D. Blossom infection: loose bunt of wheat
    - 1. Host plant
    - 2. Symptoms and signs
    - 3. Life cycle
    - 4. Epiphytology
    - 5. Control
    - 6. Life cycle
  - E. Local infection
    - 1. Host plants
    - 2. Symptoms and signs
    - 3. Epiphytology
    - 4. Life cycle
    - 5. Control
  - F. Shoestring root rot (armillaria)
    - 1. Host plants
    - 2. Symptoms and signs
    - 3. Epiphytology
    - 4. Life cycle
    - 5. Control
  - G. Powdery mildew of cereals
    - 1. Host plants
    - 2. Symptoms and signs
    - 3. Epiphytology
    - 4. Life cycle
    - 5. Control

III. Plant diseases due to Viruses
  - A. Introduction
    - 1. Significance
    - 2. Symptoms
    - 3. Properties
    - 4. Transmission
    - 5. Host ranges
    - 6. Resistance
    - 7. Nomenclature
  - B. Tobacco (tomato) mosaic
    - 1. Host plants
    - 2. Symptoms
    - 3. Etiology
    - 4. Control
  - C. Virus diseases of potatoes
    - 1. Fourteen viruses
      - a. Latent mosaic virus
      - b. Vein—banding virus
      - c. Mild mosaic virus
      - d. Spindle tuber virus
      - e. Leaf roll virus
    - 2. Control of potato viruses
      - a. Virus—free tubers
      - b. Seed inspection
      - c. Field practices
      - d. Resistant varieties

IV. Plant Diseases Due to Nematodes
  - A. Root knot
    - 1. Host plants, 1400+
    - 2. Symptoms, signs
    - 3. Etiology
    - 4. Epiphytology
    - 5. Control
      - a. Field crop
      - b. Fruit orchards
      - c. Vegetables
      - d. Nurseries
      - e. Greenhouses
  - B. Other nematodes
    - 1. Hosts
    - 2. Symptoms, signs
    - 3. Etiology
    - 4. Epiphytology
    - 5. Control

V. Insects: Development, Metamorphosis, Anatomy, Mouthparts, Orders
  - A. Phylum Arthropoda
  - B. Development
    - 1. Without metamorphosis
    - 2. Gradual metamorphosis
    - 3. Complete metamorphosis
  - C. Morphology
    - 1. External anatomy
    - 2. Internal anatomy
  - D. Mouthparts
    - 1. Biting and chewing
    - 2. Piercing and sucking
  - E. Classification: about 20 orders
    - 1. With wings
    - 2. Without wings
  - F. Springtail order
  - G. Grasshopper order
    - 1. Cockroaches
    - 2. Grasshoppers
    - 3. Crickets
  - H. Termite order
  - I. Earwig order
  - J. Thrips order

K. Dragonfly order
L. Anoplura order
  1. Biting lice suborder
  2. Sucking lice suborder
M. "True Bug" order
N. Homoptera suborder
  1. Leaf hoppers
  2. Scale insects
  3. Aphids
O. Moths and butterflies
P. The beetles
  1. Dominant order of insects
  2. Harmful in adult and larval stages
Q. The flies
R. The fleas
S. Hymenoptera order
  1. Bees
  2. Wasps
  3. Ants

VI. Insects: Study of Selected Orders
  A. The Collembola (Springtails)
    1. Wingless
    2. Slight metamorphosis
  B. The Odonata (Dragonflies)
    1. Predaceous
    2. Long abdomen
    3. Eat harmful insects
  C. The Orthoptera (Grasshoppers, etc.)
    1. Biting mouthparts
    2. Crop eaters
    3. Control
  D. The Isoptera (Termites)
    1. Social insect
    2. Destroy wood products
    3. Control
  E. The Dermaptera (Earwigs)
    1. Leathery front wings
    2. Destroys crops, flowers
    3. Control
  F. The Order Anoplura
    1. Suborder Mallophaga (biting lice)
      a. External parasites
      b. Control
    2. Suborder Siphunculata (sucking lice)
      a. External parasites
      b. Transmit diseases
      c. Control
  G. The Thysanoptera (Thrips)
    1. Winged or wingless
    2. Piercing mouthparts
    3. Suck plant sap
    4. Cause crop damage
    5. Control
  H. The Order Hemiptera (the bugs)
    1. Suborder Heteroptera (chinch bugs, assassin bugs, etc.)
      a. Crop damage types; bedbugs
      b. Control
    2. Suborder Homoptera (scale insects, plant lice, etc.)
      a. Severe crop damage types
      b. Control
  I. The Coleoptera (the beetles)
    1. Probably the dominant order of insects
    2. Majority are vegetarian in adults and larvae
    3. Severe crop damage types
    4. Control
  J. The Lepidoptera (butterflies, moths)
    1. One of largest orders of insects
    2. Many important as plant pollinators
    3. Most caterpillars are vegetarian—plant damagers
    4. Control
  K. The Siphonaptera (the fleas)
    1. External parasites
    2. Control
  L. The Hymenoptera (wasps, bees, ants, etc.)
    1. Large order
    2. Many bees are crop pollinators
    3. Social insects in many cases
    4. Control

VII. Disease and Insect Control
  A. Legislative
  B. Artificial
    1. Physical
    2. Cultural
    3. Pesticides
      a. Contact
      b. Stomach poisons
    4. Sprays, dusts, and surfactants fumigants
    5. Formulations
    6. Resistance
  C. Equipment
    1. Hand powered
    2. Machine powered
      a. Ground
      b. Aircraft
  D. Biological

    1. Insect parasites
    2. Other organisms—micro-organisms

VIII. Animal Pests and Controls
  A. Mammals
    1. Opossums
    2. Skunks
    3. Field mice
    4. Rats
    5. Ground squirrels
    6. Rabbits
    7. Pocket gophers
    8. Deer
  B. Control
    1. Poison baits
    2. Trapping
    3. Shooting
    4. Fencing
    5. Natural enemies

IX. Safety Precautions, Laws
  A. Safety
    1. Many compounds extremely toxic
    2. Sanitation
    3. Read the label
    4. Follow directions
  B. Precautions
    1. Destroy poison containers after use
    2. Keep poisons locked up
  C. Laws
    1. Federal legislation
    2. State laws
      a. On DDT, etc.
      b. Some compounds handled only by State licensed personnel
    3. County ordinances

Suggested Laboratory Projects (48 hours)

1. Identify fire blight of pear and crown gall. (3 hours)
2. Diagnose rusts and smuts. (3 hours)
3. Apply knowledge of armillaria rot and sweet potato soft rot. (3 hours)
4. Differentiate among tomato mosaic, aster yellows, and curly top of sugar beet. (3 hours)
5. Evaluate root knot, nematode problems. (3 hours)
6. Make a study of insect development and metamorphosis. (3 hours)
7. Study anatomy of the grasshopper. (3 hours)
8. Find the differences in the mouthparts of insects, and classification. (3 hours)
9. Identify silver fish, dragonflies, grasshoppers. (3 hours)
10. Study termites, earwigs, flies. (3 hours)
11. Identify thrips, true bugs, aphids, scales. (3 hours)
12. Study beetles, butterflies, moths, flies. (3 hours)
13. Identify ants, wasps, bees. (3 hours)
14. Apply disease and insect control methods. (3 hours)
15. Evaluate control of animal pests. (3 hours)
16. Consider safety, laws, quarantines. (3 hours)

Texts and References

BORROR *and* DELONG, *An Introduction to The Study of Insects*

HELLYER, *Garden Pests and Diseases*

MCSWAN *and* POWELSON, *Oregon Plant Disease Control Handbook*

METCALF *and* FLINT, *Destructive and Useful Insects: Their Habits and Control*

PFADT, *Fundamentals of Applied Entomology*

SHURTLEFF, *How To Control Plant Disease in Home and Garden*

WESTCOTT, *Gardener's Bug Book*

WESTCOTT, *Plant Disease Handbook*

Visual Aids

Chevron Chemical Co., 200 Bush Street, San Francisco, Calif. 94120
  World of Insects, 16mm., sound, color, 22 minutes

Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
  Bacteria, 16mm., sound, color, 19 minutes

Sterling Movies U.S.A., Inc., 43 South 61st Street, New York, N.Y. 10023
  The Enemy Below, 16mm., sound, color, 20 minutes

The Venard Organization, 113 North Madison Avenue, Peoria, Ill. 61602
  Stop Rats Forever, 16mm., sound, color, 14½ minutes

Union Pacific Railroad, Motion Picture Bureau, 1416 Dodge Street, Omaha, Nebr. 68102
  Wheat Smut Control, 16mm., sound, color, 10 minutes

Filmstrips:

Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
  Insects: How They Live and Grow, 35mm., 42 frames, color
  Insects: What They Are, 35mm., 42 frames, color
  Insects, Their Life Cycles, 35mm., 42 frames, color
  Helpful and Harmful Insects, 35mm., 42 frames, color

Insect Life Cycles:
Beetles and Life Cycles, 35mm., 33 frames, color
The Grasshopper, 35mm., 33 frames, color

The Insects:
What Is An Insect? 35mm., 50 frames, color
Insects That Live In Societies, 35mm., 50 frames, color
The Life Cycle of Insects, 35mm., 50 frames, color

Orders of Insects:
(All: 35mm., 45 frames, color)
Some Primitive Insects
Grasshopper and Relatives
Ants, Bees, Wasps
Bugs and Relatives
Moths and Butterflies
Beetles
Flies and Mosquitoes
Termites and Minor Orders

Charts and Pictures:
Nasco, Fort Atkinson, Wis. 53538
Riker Mount of Harmful Insects
Riker Mount of Beetles
Riker Mount of Beneficial Insects
Riker Mount of Ten Orders of Insects
Riker Mount of Metamorphosis
General Biological Supply House, Inc., 8200 South Hoyne Avenue, Chicago, Ill. 60620
Microscopic slides of insects
Microscopic slides of plant diseases
Ward's Natural Science Establishment, Inc., Post Office Box 1712, Rochester, N.Y. 14603
Microscopic slides of insects
Microscopic slides of plant diseases

Plant Propagation

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course designed to acquaint the student with the commercial methods followed in the propagation of crop plants and fruits. The reproduction of these plants by seeds, cutting, grafts, layers, runners, and divisions are covered. Laboratory sessions are planned to give the student practice in plant propagation. Sufficient practice is given to enable him to develop the skills required to propagate by the various methods.

The instructor will cover the main sections of the course: structures, media, seed growing from germination to transplanting the large plant. This will be continued with the asexual methods of propagation: the various kinds of cuttings, grafting, and budding. Then layering, specialized roots and stems, and propagation of specific fruits, nuts, and some ornamentals of commercial importance will be studied. To supplement the lecture, demonstrations, and discussion groups, motion pictures on specific items, 2- by 2-inch and color slides should be used.

The laboratory periods emphasize in more practical detail the subjects taken up in the lecture-discussion sessions. The laboratory starts with the seed: Structure, germination factors, viability tests conducted by the students, and the practical seeding of actual crops. Later the instructor has students transplant seedlings and set them out in the field. Students make cuttings of hardwood, semihardwood, and softwood for the first sessions of vegetative propagation. Asexual propagation continues with grafting done by the students —demonstrated first by the instructor as in the sections above—of root, crown, whip, cleft, side, saw, keft, and bark methods. Some attention is given by the group to repair grafting by the bridge, inarching, and brace methods. Following demonstrations by the instructor using models and actual materials, the students make buddings of plants by the "T" chip, patch, and "I" methods.

Along with the above operations at the proper times, the instructor shows students construction, heating, cooling, and operations of forcing structures. As part of the laboratory work, students gain proficiency in using the greenhouses by actually performing the necessary operations. Some work is given in layout of orchard and nursery plots.

Demonstrations are given by the instructor of propagation by layers, suckers, runners, separation, and division of some specific plants.

To better enable students to realize the economics of the industry, a field trip is scheduled through a large commercial nursery so that students will acquire an appreciation of the scope of the operation, capital needed, and the importance of the timing of operations, together with the botanical aspects of the field.

Laboratory sessions enable students to learn of the various operations in the field of plant propagation; practice in the jobs will enable them, under supervision of the instructor, to develop the skills required.

Major Divisions

		Class hours
I.	Importance and Use of Propagation	2
II.	Propagating Structure, Media, Containers	2
III.	Seeds: Development, Selection, Production, Propagation Techniques	8
IV.	Asexual Propagation: General Aspects	2
V.	Cuttings	4
VI.	Techniques of Grafting and Budding	8
VII.	Layering	2
VIII.	Specialized Roots and Stems	2
IX.	Propagation of Fruits and Nuts	2
	Total	32

Units of Instruction

- I. Importance and Use of Propagation
  - A. Objectives
    - 1. Technical skills
    - 2. Knowledge of plant growth, structure
    - 3. Specific plants and methods used
  - B. Basic reproduction types
    - 1. Sexual
    - 2. Asexual
  - C. Plant Nomenclature
    - 1. Botanical classification
    - 2. Classification of cultivated plants
      - a. Genus
      - b. Species
      - c. Cultivar

- II. Propagating Structures, Media, Containers
  - A. Propagating structures
    - 1. Glasshouses
      - a. Forms
      - b. Heating
      - c. Cooling
      - d. Humidity
    - 2. Plastic greenhouses
    - 3. Hotbeds
    - 4. Coldframes
    - 5. Lathhouses
    - 6. Clothhouses
  - B. Media for propagating and growing container stock
    - 1. Soil
    - 2. Sand
    - 3. Peat
    - 4. Sphagnum moss
    - 5. Vermiculite
    - 6. Perlite
    - 7. Leaf mold
    - 8. Sawdust, shavings
  - C. Mixtures
  - D. Sterilization
    - 1. Heat
    - 2. Chemicals
  - E. Fertilizers
  - F. Containers for young plants
    - 1. Flats
    - 2. Clay pots
    - 3. Plastic pots, trays
    - 4. Peat fiber pots
    - 5. Plant bands
  - G. Handling containers

- III. Seeds: Development, Selection, Production, Propagation Techniques
  - A. Development of flower
  - B. Fertilization
  - C. Apomixis
  - D. Morphology
    - 1. Embryo
    - 2. Food storage tissues
    - 3. Covering
  - E. Seed selection
    - 1. Uses of seedlings
    - 2. Pollination requirements of plants
      - a. Self-pollinated
      - b. Cross-pollinated
    - 3. Maintaining purity
      - a. Isolation
      - b. Roguing
      - c. Certification
        - (1) Breeder's seed
        - (2) Foundation seed
        - (3) Registered seed
        - (4) Certified seed
    - 4. Hybrid seed production
    - 5. Seed selection of woody perennials
    - 6. Mother trees
  - F. Seed production and handling
    - 1. Sources of seed
      - a. Commercial seed production
      - b. Seed collecting

    - c. Fruit processing industries
  - 2. Harvesting and handling seeds
  - 3. Factors affecting storage of seeds
    - a. Temperature
    - b. Moisture
    - c. Storage atmosphere
  - 4. Types of seed storage
    - a. Dry, without temperature control
    - b. Cold, dry
    - c. Cold, moist
- G. Seed propagation
  - 1. Germination process
  - 2. Viability
  - 3. Measurement of germination
  - 4. Seed dormancy
    - a. Coverings
    - b. Internal factors
  - 5. External factors affecting germination
    - a. Water
    - b. Temperature
    - c. Oxygen
    - d. Light
  - 6. Seed testing
    - a. Sampling
    - b. Purity
    - c. Viability
  - 7. Pregermination treatments to stimulate germination
    - a. Mechanical
    - b. Soaking
    - c. Acid scarification
    - d. Cold scarification
  - 8. Timing planting
  - 9. Disease and soil treatment
  - 10. Germinating media
  - 11. Aseptic culture
  - 12. Field direct seeding
  - 13. Transplanting

IV. Asexual Propagation: General Aspects
- A. Nature and importance
  - 1. The clone
  - 2. Reasons for using asexual propagation
    - a. Perpetuation of a clone
    - b. Impossibility of seed propagation
    - c. Ease of propagation
- B. Genetic variation
  - 1. Mutations
  - 2. Chimeras
- C. Plant patent law

V. Cuttings
- A. Anatomical development of roots in cuttings
  - 1. Stem
  - 2. Leaf
  - 3. Root
- B. Physiological basis of root initiation in cuttings
  - 1. Hormones
  - 2. Auxins
  - 3. Calines
- C. Selection of cutting material
  - 1. Nutrition of stock plant
  - 2. Age of stock plant
  - 3. Type of wood selected
  - 4. Time of year
- D. Treatment of cuttings
  - 1. Presence of buds and leaves
  - 2. Polarity
  - 3. Wounding
  - 4. Growth regulators
- E. Environmental conditions during rooting
  - 1. Humidity
  - 2. Mist propagation
  - 3. Temperature
  - 4. Light
  - 5. Rooting medium
- F. Practical techniques of making cuttings
  - 1. Stem
    - a. Hardwood
    - b. Semihardwood
    - c. Softwood
    - d. Herbaceous
  - 2. Leaf cuttings
  - 3. Leaf-bud cuttings
  - 4. Root cuttings
  - 5. Rooting media
  - 6. Wounding
  - 7. Growth regulators
    - a. Materials
    - b. Concentrations: dip, dry
  - 8. Mist systems
  - 9. Hardening off
  - 10. Care

VI. Techniques of Grafting and Budding
- A. Theoretical aspects
  - 1. Reasons for use
  - 2. Formation of graft union
  - 3. Factors influencing healing of graft or bud union

- a. Incompatibility
- b. Temperature and humidity
- c. Chemicals
- d. Polarity

4. Limits of grafting
5. Effects of rootstock on scion variety
6. Effects of scion variety on rootstock

B. Practical techniques of grafting
  1. Definition of terms
    - a. Scion
    - b. Stock
    - c. Cambium
    - d. Callus
    - e. Stion
  2. Points for success in grafting
  3. Methods of grafting
    - a. Whip or tongue
    - b. Side graft
    - c. Cleft graft
    - d. Saw kerf (notch) graft
    - f. Approach grafting
    - g. Inarching
    - h. Bridge graft
    - i. Bracing
  4. Tools and accessories
    - a. Knives
    - b. Waxes
    - c. Tying and wrapping materials
    - d. Grafting machines
    - e. Proper sharpening techniques
  5. Selection of scion wood and storage
  6. Grafting by placement
    - a. Root grafting
    - b. Crown grafting
    - c. Double-working
    - d. Top-working

C. Techniques of budding
  1. Time of budding
    - a. Fall
    - b. Spring
    - c. June
  2. Methods of budding
    - a. "T" (shield)
    - b. Inverted "T"
    - c. Patch
    - d. Flute
    - e. Ring or annular
    - f. "I" budding
    - g. Chip
    - h. Top

VII. Layering
  - A. Factors affecting
  - B. Characteristics and uses of layering
  - C. Procedures in layering
    1. Tip
    2. Simple
    3. Compound or serpentine
    4. Air
    5. Mound (stool)
    6. Trench

  - D. Plant modifications giving natural layering
    1. Runners
    2. Stolons
    3. Offsets
    4. Suckers
    5. Crowns

VIII. Specialized Roots and Stems
  - A. Bulbs
    1. Offsets
    2. Bulblet formation
    3. Stem cuttings
    4. Leaf cuttings
  - B. Corms
  - C. Tubers
  - D. Tubercles
  - E. Tuberous roots
  - F. Rhizomes
  - G. Pseudobulbs
  - H. Back bulbs, green bulbs

IX. Propagation Of Fruits and Nuts
  - A. Almond
  - B. Apple
  - C. Apricot
  - D. Avocado
  - E. Cherry
  - F. Chestnut
  - G. Citrus
  - H. Fig
  - I. Grape
  - J. Nectarine and peach
  - K. Olive
  - L. Pear
  - M. Pecan
  - N. Persimmon
  - O. Pomegranate
  - P. Plum
  - Q. Quince
  - R. Walnut

Suggested Laboratory Projects (48 hours)

1. Determine seed structure. (3 hours)
2. Study germination factors. (3 hours)
3. Make viability tests. (3 hours)
4. Plant seeds in flats. (3 hours)
5. Make cuttings of hardwood. (3 hours)
6. Graft by root, crown, whip (tongue) methods. (3 hours)
7. Top graft by cleft, whip, side, saw kerf, bark methods. (3 hours)
8. Transplant seedlings. (3 hours)
9. Practice repair grafting: bridge, inarching brace grafting. (3 hours)
10. Use forcing structures. Potting, shifting, balling plants or laying out nursery growing grounds or laying out an orchard; planting trees. (3 hours)
11. Do budding by "T" (shield) method. (3 hours)
12. Practice budding by chip, patch, "I" methods. (3 hours)
13. Multiply plants by cuttings: semihardwood, softwood, stem, leaf, root methods. (3 hours)
14. Propagate plants by layers, suckers, runners. (3 hours)
15. Increase plants by separation and by division. (3 hours)
16. Take a field trip to a commercial nursery to study production methods. (3 hours)

Texts and References

ALLARD, *Principles of Plant Breeding*
MAYER *and* POLJAKOFF-MAYBER, *Germination of Seeds*

Visual Aids

Allis-Chalmer Manufacturing Co.,
Tractor Photographic Group,
Milwaukee, Wis. 53201
Hybrid Corn, 16mm., sound, color, 15 minutes

Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
The Growth of Plants, 16mm., sound, color, 21 minutes
Seed Germination, 16mm., sound, color, 15 minutes

Nasco, Fort Atkinson, Wis. 53538
Types of Grafting (chart)
How to Bridge Graft (chart)
Grafting Materials (chart)

Ward's Natural Science Establishment, Inc.,
Post Office Box 1712, Rochester, N.Y. 14603
Model of Plant Cell
Model of Typical Flower
Model of Fruit and Seed (wheat grain)
Model of Stem

General Biological Supply House, Inc., 8200 South Hoyne Avenue, Chicago, Ill. 60620
Model of Corn Stem
Model of Dicot Stem
Model of Generalized Dicot Flower

Seed Production

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the reproductive processes, principles of breeding, environmental response, and the harvesting and processing of seed crops. In the laboratory, the student will gain actual experience in test plot work, seed processing, and seed testing.

Since the specific principles of crop production are to be covered in other courses, this class will emphasize applied theories and practices of seed production. Class discussions will stress the practical aspects of plant structures, genetics, breeding principles and plant response to environment as related to producing seed crops. Applied techniques in the harvesting, storing, processing and testing of seed will be covered. Also the student will have an opportunity to familiarize himself with the classes of seed, seed laws and the various agencies involved in the seed trade.

During the laboratory period extensive use will be made of demonstration plots for studying plot technique and breeding methods utilized with selected crops. In the classroom laboratory the student will have an opportunity to gain actual experience in using seed germinators, seed blowers, vitascopes and other devices and techniques to evaluate seed quality. Comprehensive use will be made of seed cleaners, samplers, plot threshing machines, scarifiers, and other seed handling and processing equipment. Also field trips to seed producers and processors will allow student observation of commercial operations.

Major Divisions

	Class hours
I. Distribution and Importance of Seed Crops	2
II. Reproductive Processes of Crop Plants	4

III.	Environment and Seed Production	4
IV.	Genetics of Crop Plants	2
V.	Fundamental Plant Breeding Techniques	2
VI.	Hybridization as a Method of Plant Breeding	4
VII.	Certified Seed Production	2
VIII.	Harvesting, Transporting, Storing Seeds	4
IX.	Seed Processing	2
X.	Germination and Its Relationship to Seed Quality	2
XI.	Testing of Agricultural Seeds	2
XII.	Laws Relating to Seeds	2
	Total	32

Units of Instruction

I. Distribution and Importance of Seed Crops
- A. Importance
  - 1. Uses of seed
    - a. Seed stocks
    - b. Human food
    - c. Animal feed
    - d. Industrial uses
  - 2. Economic value of seed crops
  - 3. Foreign trade in seed
  - 4. Reservoirs of germ plasm
  - 5. Perpetuators of undesired species
- B. Geographical areas of production
  - 1. Areas of production of specific seed crops
  - 2. Interstate movements of seed
- C. History of seeds
  - 1. Importation of foreign stocks
  - 2. Exportation of American stocks
- D. Statistics and trends
  - 1. Forecast and estimates
  - 2. Trends in seed production

II. Reproductive Processes of Crop Plants
- A. Sexual reproduction of crop plants
  - 1. Types of flowers
    - a. Complete
    - b. Incomplete
    - c. Perfect
    - d. Imperfect
  - 2. Types of plants
    - a. Monoecious
    - b. Dioecious
  - 3. Reproductive structures
    - a. Calyx
    - b. Corolla
    - c. Stamen
    - d. Pistil
  - 4. Processes leading to seed development
    - a. Formation of stamens and pistils
    - b. Sexual maturity
    - c. Pollination
    - d. Fertilization
    - e. Growth of the fertilized egg
    - f. Maturation of the seed
  - 5. Self- and cross-pollinated plants
    - a. Naturally self-pollinated
    - b. Often cross-pollinated
    - c. Naturally cross-pollinated
  - 6. Factors affecting natural selfing and crossing
    - a. Variety of strain
    - b. Seasonal conditions
    - c. Floral arrangements
    - d. Incompatibility
    - e. Maturity of pollen and stigma
- B. Asexual propagation of crops
  - 1. Methods of propagating crop plants vegetatively
    - a. Separation and division
    - b. Cuttings
    - c. Layerage
  - 2. Use of clones in plant breeding
  - 3. Apomixis

III. Environment and Seed Production
- A. Photoperiodic response
  - 1. Short day plants
  - 2. Long day plants
  - 3. Day-neutral plants
  - 4. Photoperiodic induction
  - 5. Amount of light required for photoperiodic response
  - 6. Light quality and photoperiodic response
  - 7. Color spectrum and photoperiodic response
  - 8. Sequence of processes in photoperiodism
  - 9. Photoperiodism and vegetative growth
  - 10. Artificial light
- B. Response to thermatic conditions
  - 1. Relationship to photoperiodic response
  - 2. Vernalization
  - 3. Effect on pollination and fertilization

- C. Effect of wind velocity and direction on seed production
  - 1. Beneficial aspects
  - 2. Detrimental aspects
- D. Effect of seasonal conditions on seed production
- E. Effect of insect populations on seed production
  - 1. Crops pollinated by insects
    - a. Leguminosae
    - b. Cruciferae
    - c. Allium
    - d. Umbelliferae
    - e. Curcurbitaceae
    - f. Cotton
    - g. Tomato
  - 2. Use of bees in pollinating crops
  - 3. Detrimental insects (seed attacking insects)
    - a. Lygus bugs
    - b. Chalcids
    - c. Stink bugs
    - d. Midges
    - e. Seed weevils
    - f. Corn borer
    - g. Corn earworms
    - h. Sorghum webworm
    - i. English grain aphid
    - j. Chinch bugs
  - 4. Other detrimental aspects of insects
- F. Effect of soil fertility and pH on seed production
- G. Relationship of moisture to seed production
- H. Effect of cultural practices on seed quality
  - 1. Planting procedures
  - 2. Irrigation
  - 3. Fertilization
  - 4. Insect pest control
  - 5. Weed control
  - 6. Harvesting

IV. Genetics of Crop Plants

- A. Determiners of hereditary variations
  - 1. Chromosomes
    - a. Meiosis
    - b. Fertilization
  - 2. Genes
  - 3. Significance of variation
    - a. Environmental variation
    - b. Genetic variation
- B. Inheritance of characters
  - 1. Law of segregation
    - a. Gene locus
    - b. Alleles
    - c. Homozygous and heterozygous genes
  - 2. Law of dominance
    - a. Dominance
    - b. Recessiveness
    - c. Incomplete dominance
  - 3. Law of independent assortment
    - a. Phenotypic ratios
    - b. Geneotypic ratios
    - c. Linkage
    - d. Crossing over
  - 4. Gene interactions
    - a. Complementary action
    - b. Modifying action
    - c. Inhibiting action
    - d. Masking action
    - e. Duplicate action
    - f. Additive effect
  - 5. Mutations
    - a. Causes of mutations
    - b. Occurrence of mutations
    - c. Methods of initiating mutations
  - 6. Polyploidy
    - a. Types of polyploidy
    - b. Methods of initiating polyploidy

V. Fundamental Plant Breeding Techniques

- A. Introduction
  - 1. Acclimatization
  - 2. Testing
  - 3. Development of ecotypes
  - 4. Commercial varieties emerging from introductions
    - a. Grow the introduction en masse
    - b. Selection of desirable strains of introductions
    - c. Use of introductions as parental lines in crossing
- B. Selection
  - 1. Mass selection
    - a. Definition of technique
    - b. Weaknesses of mass selection
    - c. Selection of phenotypes
    - d. Use of mass selection in plant breeding
  - 2. Pure line selection
    - a. Pure line theory

        - b. Procedure for making pureline selections
        - c. Genetic stability of purelines
        - d. Use of multiline varieties
        - e. Progeny testing
        - f. Natural selection
        - g. Use of pureline selection in plant breeding
    - 3. Recurrent selection
- C. Hybridization
    - 1. Hybrid vigor or heterosis
        - a. Definition of hybrid vigor
        - b. Theories of hybrid vigor
        - c. Utilization of hybrid vigor in plant breeding
    - 2. Use of male sterility in producing hybrids
    - 3. Interspecific hybridization
        - a. Crosses of cross-fertile species
        - b. Crosses which lead to doubling of the chromosome number
        - c. Crosses of species with different chromosome numbers
    - 4. Intergeneric crosses
    - 5. Selection procedures and hybridization
        - a. Pedigree selection
        - b. Bulk population
    - 6. Backcross method of producing hybrids
        - a. Objectives of backcrossing
        - b. Recurrent parent
        - c. Nonrecurrent parent

VI. Hybridization as a Method of Plant Breeding

- A. Selfing and crossing
    - 1. Emasculation practices
        - a. Removal of anthers
        - b. Killing pollen by physical or chemical methods
        - c. Use of self-incompatible lines
        - d. Use of male sterility
    - 2. Pollination practices
        - a. Collection of pollen
        - b. Storage of pollen
        - c. Pollinating by hand
        - d. Using insects
        - e. Pollination problems
    - 3. Control of flowering
        - a. Temperature control
        - b. Light regulation
        - c. Vernalization
    - 4. Factors to consider in evaluating hybrids
        - a. Region of production
        - b. Number of plants per acre
        - c. Environmental conditions
        - d. Cultural practices
- B. Methods of producing commercial hybrids
    - 1. Production of inbred lines
    - 2. Single cross hybrids
    - 3. Double cross hybrids
    - 4. Threeway cross hybrids
    - 5. Multiple cross hybrids
    - 6. Top crossing
- C. Production of hybrid corn
    - 1. Process of producing corn hybrids
        - a. Producing and selecting inbred lines
        - b. Crossing inbred lines and evaluating their progeny
    - 2. Hybrid vigor in corn
    - 3. Techniques utilized in crossing
        - a. Detasseling
        - b. Use of male sterile seed plants
        - c. Use of cytoplasmic sterile female plants
        - d. Ratio of male to female plants
    - 4. Evaluating corn hybrids
        - a. Yields
        - b. Adaptability to environment
        - c. Insect resistance
        - d. Disease resistance
        - e. Lodging resistance
        - f. Resistance to ear dropping
        - g. Suitability to mechanical harvesting
        - h. Quality
    - 5. Hybrids v. open pollinated varieties
- D. Production of hybrid sorghums
    - 1. Production of inbred lines
    - 2. Crossing of inbred lines
        - a. Use of Day male sterility
        - b. Use of cytoplasmic male sterility
    - 3. Interspecific crosses
    - 4. Hybrid vigor in sorghums
    - 5. Evaluating sorghum hybrids
        - a. Yields
        - b. Adaptability to environment
        - c. Early maturity
        - d. Insect resistance

        - e. Disease resistance
        - f. Quality
        - g. Suitability to mechanical harvesting
        - h. Resistance to lodging and shattering
    - 6. Hybrids v. open pollinated varieties

VII. Certified Seed Production
- A. The certification system
    - 1. Definition of certified seed
    - 2. Agencies involved in breeding and certifying seeds
        - a. International Crop Improvement Association
        - b. Agricultural Experiment Stations
        - c. Agricultural Extension Service
        - d. State crop improvement associations
        - e. State departments of agriculture
        - f. U.S. Department of Agriculture
        - g. Private organizations
    - 3. Types of seeds eligible for certification
- B. Classes of seed
    - 1. Breeder seed
    - 2. Foundation seed
    - 3. Registered seed
    - 4. Certified seed
- C. Certification requirements
    - 1. Isolation
        - a. Boundaries
        - b. Cross pollinating crops
        - c. Certifying part of a field
    - 2. Field free of undesirable plants
        - a. Noxious weeds
        - b. Volunteer plants of same crop
        - c. Roguing
    - 3. Seed treatment
- D. Certification process
    - 1. Application
    - 2. Field inspection
        - a. Dates
        - b. Standards for field inspection
        - c. Diseases
        - d. Weeds
    - 3. Harvesting
        - a. Standards in harvesting
        - b. Inspection of harvester
        - c. Grower number
    - 4. Intercounty movement of unprocessed seed
    - 5. Processing
        - a. Supervision
        - b. Requirements
    - 6. Sampling and testing
    - 7. Final certification, sealing, and tagging
    - 8. Fees involved in certification
- E. National Foundation seed project
    - 1. Purposes of the project
    - 2. Distribution of seed stocks

VIII. Harvesting, Transporting, Storing Seeds
- A. Harvesting seed crops
    - 1. Factors to consider in harvesting
        - a. Variations in physical characteristics of seed
        - b. Type of plant
        - c. Size of plant
        - d. Maturity of seed
        - e. Time of harvest
    - 2. Harvesting equipment
        - a. Conventional combines
        - b. Combines with special modifications
        - c. Seed strippers
        - d. Grain binders
        - e. Headers
        - f. Threshing machines
        - g. Melon combines
        - h. Vacuum seed reclaimers
        - i. Windrowers
    - 3. Harvesting practices
        - a. Determine when to harvest
        - b. Curing methods
        - c. Use of defoliants
        - d. Combining or threshing
        - e. Harvesting losses
- B. Transportation of seed
    - 1. Railroad shipments
    - 2. Motor carriers
        - a. Exempt carriers
        - b. Nonexempt carriers
    - 3. Responsibility of shipper and carrier
    - 4. Protecting seed from damage in transit
- C. Storage of seed
    - 1. Storage facilities
        - a. Warehouses
        - b. Conditioned storage rooms
        - c. Bulk bins
        - d. Conveying systems
        - e. Packaging equipment

2. Storage conditions
    a. Protecting from adulteration
    b. Protecting from deterioration
    c. Protecting from damage
3. Spoilage of seed in storage
    a. Insect and rodent damage
    b. Molds and fungi
    c. Heating
    d. Oxidation and hydrolysis of fats
4. Storage problems
    a. Relationship of insects to fungi
    b. Relationship of molds and fungi to seed quality
    c. Relationship of moisture and temperature to seed quality
    d. Relationship of seed respiration to seed quality
5. Treating stored seed
    a. Fumigation
    b. Applications of insecticides
    c. Use of controlled heat
    d. Use of inert gases
    e. Aeration
6. Insects of stored grain
    a. Rice weevil
    b. Granary weevil
    c. Lesser grain borer
    d. Angoumois grain moth
    e. Dermestids
    f. Saw toothed grain beetle
    g. Flat grain beetle
    h. Flour beetles
    i. Cadelle
    j. Bean and pea weevils
    k. Indian metal moth (Indian meal moth)
    l. Khapra beetle

D. Post harvest drying of seeds
1. Methods
    a. Forced unheated air
    b. Heated air
2. Airflow
    a. Recommended airflow
    b. Static pressures
    c. Reverse airflow drying
3. Drying with heated air
    a. Temperature
    b. Heater, fan and vent arrangements
    c. Specialized drying processes for specific seeds
4. Costs of drying seeds
5. Effect of drying on seed
    a. Holding qualities
    b. Seed quality

IX. Seed Processing

A. Seed cleaning
1. Seed separating equipment
    a. Air screen cleaners
    b. Specific gravity separators
    c. Indent cylinder separators
    d. Indent disk separators
    e. Pneumatic and aspirator separators
    f. Spiral and inclined drapers
    g. Magnetic separators
    h. Velvet roll separator
    i. Electronic separators
    j. Color separators
2. Precleaning operations
    a. Debearding
    b. Hulling
    c. Scalping
    d. Scarifying
3. Common adulterants
    a. Inert material
    b. Weed seed
    c. Other crop seed
4. Sequence of cleaning operations

B. Special processing
1. Scarifying
    a. Methods utilized in scarifying
    b. Seeds needing scarification
2. Grading
3. Delinting cotton seed
    a. Flame process
    b. Chemical delinting
4. Decortication
5. Irradiation
6. Blending
7. Pelleting

C. Cost of cleaning seed
1. Cash costs
2. Shrinkage

D. Inoculation
1. Methods of inoculating
2. Inoculating equipment

E. Treating seed to control disease
1. Mechanical methods of treating
2. Physical methods of treating
    a. Hot water and water soak
    b. Irradiation
3. Chemical treatments

        a. Chemical compounds
        b. Slurry and quick wet methods of applying
    4. Specific treatments of seed
        a. Cereal grains
        b. Field crops
        c. Small seeded forage legumes
        d. Vegetables
        e. Large seed legumes

X. Germination and Its Relationship to Seed Quality
  A. Factors essential for germination
    1. Temperature
        a. Threshold temperature
        b. Optimum
        c. Maximum
        d. Relationship of temperature to molds and fungi
    2. Moisture
    3. Oxygen
    4. Light
        a. Requirements
        b. Response to color spectrum
  B. Process of Germination
    1. Absorption of water
    2. Softening of seed coat and swelling of seed
    3. Hydrolysis and utilization of starch
        a. Starch to maltose
        b. Maltose to glucose
        c. Translocation of glucose
        d. Synthesis of carbohydrate materials from glucose
    4. Nitrogen metabolism
        a. Hydrolysis of protein into amides and amino acids
        b. Resynthesis of proteins
    5. Fat breakdown and synthesis
        a. Fats to fatty acids and glycerol
        b. Fatty acids and glycerol to sugar
        c. Synthesis of carbohydrates and fats from sugar
    6. Growth of the embryo
        a. Epigeal germination
        b. Hypogeal germination
  C. Dormancy
    1. Causes of dormancy
        a. Seed coats inhibiting water intake
        b. Seed coats inhibiting oxygen intake
        c. Immature embryos
        d. Chemical inhibitors
    2. Overcoming dormancy
        a. Aging of seed
        b. Temperature treatments
        c. Reduction of moisture content
        d. Breaking of seed coat
    3. Secondary dormancy
  D. Longevity of seed
    1. Storage life of seeds
    2. Effect of microenvironment on longevity
  E. Conditions affecting germination
    1. Mechanical injury
    2. Fungi and bacteria
    3. Storage conditions
    4. Fumigation
    5. Artificial drying
    6. Storage temperature

XI. Testing of Agricultural Seeds
  A. Sampling
    1. Equipment for sampling
    2. Sampling procedure
    3. Splitting the sample
  B. Purity
    1. Equipment
    2. Evaluation of damaged seed
    3. Formulas in calculating adulteration
    4. Weed seed
    5. Sterile florets of grass seed
    6. Evaluation of pure viable seed
    7. Special tests for purity
  C. Germination
    1. Standard germination procedures
        a. Germinators
        b. Temperature, humidity, substrata
        c. Interval of time
        d. Cold test
        e. Hard seed
        f. Special treatments
        g. Evaluating germination tests
    2. Tetrazolium testing for germination
        a. Theory of tetrazolium testing
        b. Testing equipment
        c. Testing techniques
        d. Evaluating tetrazolium tests
  D. Methods of testing seeds for moisture
    1. Air oven
    2. Vacuum oven
    3. Toluene distillation
    4. Brown-Duvel distillation

        5. Dessicants
        6. Electric moisture testers
        7. Vapor pressure methods
    E. Seed testing agencies
        1. Federal-State cooperative laboratories
        2. Private laboratories

XII. Laws Relating to Seeds
    A. Federal Seed Act
        1. Background
            a. Basic purposes
            b. Historical development
        2. Provisions of the Federal Seed Act: Importation of Seed
            a. Seeds covered by act
            b. Prohibitions and procedures relating to importations
            c. Exemptions
            d. Declarations of purpose and labeling
            e. Seed unfit for seeding purposes
            f. Staining of certain imported seeds
        g. Misbranded seed
            h. Mixing seed
            i. Exportation or destruction of rejected seed
            j. Prohibition of certain acts
            k. Trademarks and patents
        3. Provisions of the Federal Seed Act: Interstate Commerce
            a. Prohibitions
            b. Exemptions
            c. Disclaimers and nonwarrantees
            d. False advertising
        4. Records required by the Federal Seed Act
            a. Lot numbers
            b. Receiving records
            c. Growers declarations
            d. Processing records
            e. Disposition records
            f. Test records
            g. Labeling records
            h. File samples
    B. State seed laws
        1. Federal-State cooperation
            a. State enforcement
            b. Referral of violation to U.S. Department of Agriculture
        2. State quarantine laws
            a. Noxious weeds and other adulterants
            b. Insect pests
    C. Exportation of seed

Suggested Laboratory Projects (48 hours)

1. Study the reproductive structures of crop plants. (3 hours)
2. Study experimental plot technique and layout several test plots. (3 hours)
3. Identify crop seed. (3 hours)
4. Identify noxious weed seed and other adulterants. (3 hours)
5. Judge crop seed. (3 hours)
6. Identify seedborne diseases. (3 hours)
7. Study seed inoculation procedures and inoculate legume seeds. (3 hours)
8. Identify insects that are detrimental to seeds. (3 hours)
9. Practice hybridization of small grains. (3 hours)
10. Visit a local seed house. (3 hours)
11. Clean the seed of selected crops. (6 hours)
12. Test the seed of selected crops. (6 hours)
13. Visit a seed testing laboratory. (3 hours)
14. Visit the experimental breeder plots of a commercial seed organization. (3 hours)

Texts and References

MARTIN *and* BARKLEY, *Seed Identification Manual*

U.S. Department of Agriculture, *Manual For Testing Agricultural and Vegetable Seeds*

Small Fruit Production

Hours Required

Class, 2: Laboratory, 3.

Course Description

This course is designed to acquaint the student with the various phases of producing grapes, bushberries, and strawberries. The course will cover all cultural practices including design of the planting area, establishing young plants, fertilization, irrigation, pest control, and harvesting.

The instructor will devote the lecture time to those small fruits of his general geographical area or of major economic significance to the local market. Costs of production and trends will be emphasized.

Laboratory exercises are designed to give the student the basic information and skills necessary for the production of small fruits. Considerable laboratory time is devoted to study of growing conditions and the practice of manipulative skills in the small fruit area of the school farm.

Students will have an opportunity to conduct tests and demonstrations in the school vineyard and berrygrowing area.

Major Divisions

		Class hours
I.	Geographical Distribution	2
II.	Suitable Soil and Climatic Conditions	2
III.	Designing and Planning the Orchard or Vineyard	2
IV.	Plant Propagation	2
V.	Soil Preparation and Planting	2
VI.	Irrigation	2
VII.	Weed Control, Cultivation, Erosion Control	2
VIII.	Fertilization and pH	2
IX.	Diseases of Small Fruits	3
X.	Insects, Nematodes, Other Pests	3
XI.	Grape Growing: Special Problems	4
XII.	Strawberry Production: Special Problems	2
XIII.	Bushberry Production: Special Problems	2
XIV.	Miscellaneous Fruits and Berries: Special Problems	2
	Total	32

Units of Instruction

- I. Geographical Distribution
  - A. National
  - B. Regional
  - C. Local
    - 1. Important species
    - 2. Trends
    - 3. Adaptation
      - a. Annual climate
      - b. Disadvantages
      - c. Major local advantages
    - 4. Labor sources
    - 5. General topography
- II. Suitable Soil and Climatic Conditions
  - A. Soil
    - 1. Adaptation: types, depth
    - 2. Water table
    - 3. pH and salts
    - 4. Nutrients
    - 5. Organic matter
  - B. Climate
    - 1. Winter chill
      - a. Length below 45° F
      - b. Actual temperature: year study
      - c. Frosts: spring and fall
    - 2. Summer
      - a. Maximum temperatures
      - b. Degree days required for economic crops
    - 3. Winds
    - 4. Humidity
    - 5. Precipitation
      - a. Amount
      - b. Frequency
- III. Designing and Planning the Orchard or Vineyard
  - A. Factors to consider
    - 1. Type of planting
      - a. Rectangular system
      - b. Contour system
      - c. Triangle system
      - d. Hedge system
    - 2. Field size and shape
    - 3. Slope and conservation practices
    - 4. Irrigation methods, soil type
    - 5. Drainage facilities
    - 6. Equipment, tractor sizes
    - 7. Harvest operations
    - 8. Residence
    - 9. Wind direction
    - 10. General topography
    - 11. Supporting structures
  - B. Sources of professional help
    - 1. Farm advisors
    - 2. Surveying companies
    - 3. Visit local successful growers
    - 4. Soil conservation district
    - 5. Local watershed district
- IV. Plant Propagation
  - A. Sexual
    - 1. Problems of maintaining characteristics
    - 2. Stratification requirements
    - 3. Development of new strains and varieties
  - B. Asexual

        1. Definition and advantages
        2. Cuttings
            a. Leaf-bud: blueberry
            b. Root: blackberries
            c. Stem: grape, cranberries
            d. Root hormones
            e. Physical equipment and supplies
        3. Layering
            a. Definition
            b. When to use
                (1) When variety is poorly propagated by cuttings
                (2) Easy to replace occasional missing plant in established vineyard
        4. Grafting
            a. Whip
            b. Machine grafting
            c. Cleft
            d. Budding
        5. Runners (specialized stems); strawberries
        6. Suckers (stems arising from adventitious bud on a root); raspberries
        7. Division

V. Soil Preparation and Planting
    A. Factors to consider in soil preparation
        1. Planting method
            a. Rows
            b. Hills
            c. Bog
        2. Stage of growth when planted
        3. Fertility and organic matter of soil
        4. Condition of soil
            a. Moisture
            b. Tilth
        5. Topography
        6. Irrigation system
        7. Drainage program
        8. Stubble or recent crop residue condition
    B. Planting
        1. Selection of plants
            a. Sources
            b. Stage of growth
            c. General health
            d. Time of year
        2. Care of planting stock before planting: heeling and cold storage
        3. Analysis of planting systems.
            a. Plant spacing
            b. Habit of growth
            c. Cultural practices, tractor spacing, harvest methods, etc.
            d. Trellis system and training program
            e. Irrigation system
            f. Intercropping

VI. Irrigation
    A. System description and analysis
        1. Cranberry bogs
        2. Furrow: advantages and disadvantages
        3. Sprinkler: advantages and disadvantages
    B. Special problems
        1. Maintenance of high moisture through long picking season
        2. Cranberry and high moisture requirements
        3. Strawberry, daily irrigations
        4. Excessive moisture: blueberries and raspberries
        5. Drainage
        6. Grapes
            a. Moisture: sugar acid relationships
            b. Bunch rot and sprinkler irrigation
    C. Quantity of moisture needed by major small fruits per season
    D. Time and frequency of irrigation
    E. Quantity of water required for an irrigation
        1. Soil type
        2. Root zone depth
    F. Water quality

VII. Weed Control, Cultivation, Erosion Control
    A. Purpose and frequency of cultivation
        1. Destroy weeds
        2. Facilitate irrigation
        3. Facilitate harvest and drying
        4. Incorporate cover crops
        5. Pest control
        6. Promote water absorption
    B. Tillage implements for cultivation
        1. Noble and French or "Kirpy" plows
        2. Disc
        3. Various drags
        4. Various cultivators and harrows
            a. Chisel-tooth
            b. Revolving harrows

            - c. Spring-tooth harrow
            - d. Sweeps and shovels
    - C. Weed control with chemicals and oil
        - 1. Oil
        - 2. Diuron
        - 3. Monuron
        - 4. Simazine
        - 5. Atrazine
        - 6. 2, 4-D amine
        - 7. Dalapon
    - D. Other methods of weed control
        - 1. Mulch
        - 2. Geese
        - 3. Flamethrowers
    - E. Soil erosion control
        - 1. Wind breaks
        - 2. Contour plantings
        - 3. Cover crops
        - 4. Grass slope collecting ditches
        - 5. Strip cropping
        - 6. Mulch

- VIII. Fertilization and pH
    - A. The primary soil nutrients
        - 1. Nitrogen
            - a. Determining need for N (nitrogen)
            - b. Form to use
            - c. Where and when to apply
            - d. Cover crops
            - e. Use by each acre per year
        - 2. Potassium
            - a. Determining need for K (potassium)
            - b. Form to use
            - c. Where and when to apply
            - d. Use per acre per year
        - 3. Phosphorus
            - a. Determining need for P (phosphorus)
            - b. Where and when to apply
            - c. Use per acre per year
    - B. Other nutrients and small fruit production
        - 1. Calcium
        - 2. Boron
        - 3. Magnesium
        - 4. Iron
        - 5. Sodium
        - 6. Zinc
        - 7. Sulfur
        - 8. Copper
        - 9. Manganese
        - 10. Molybdenum
    - C. Fruiting and the carbohydrate nitrogen ratio
    - D. Manures and commercial fertilizers
    - E. pH
        - 1. Definition and neutral concept
        - 2. Buffers and agents to neutralize
            - a. Sulfur, sulfuric acid
            - b. Lime
            - c. Gypsum and water
        - 3. Blueberries and acid soils, 4 to 5.5

- IX. Diseases of Small Fruits
    - A. Strawberry diseases (causes, symptoms, damage, and control).
        - 1. Root and crown diseases
            - a. Verticillium wilt
            - b. Red stele
            - c. Black root rot
            - d. Armillaria root and crown rot
            - e. Other crown rots
        - 2. Virus diseases
            - a. Yellows
            - b. Crinkle
            - c. Aster yellows
        - 3. Foliage diseases
            - a. Leaf spot, blotch, and scorch
            - b. June, transient or Blakemore yellows
            - c. Tip burn
            - d. Powdery mildew
        - 4. Fruit diseases
            - a. Fruit deformity (cat face)
            - b. Gray mold rot
            - c. Other rots
                - (1) Phizoctonia (species)
                - (2) Rhizopus (species)
                - (3) Phytophthora (species)
                - (4) Sclerotium (species)
    - B. Grape diseases (cause, symptoms, damage control)
        - 1. Fungi attacking both vine and fruit
            - a. Powdery mildew
            - b. Anthracnose
            - c. Black rot
            - d. Downy mildew
            - e Dead arm
            - f. Black measles
        - 2. Fungi attacking the fruit
            - a. Blue-mold rot
            - b. Black-mold rot

- c. Rhizopus rot
- d. Botrytis (gray mold) rot
- e. Bunch rot

3. Fungi attacking roots
    - a. Oak root fungus
    - b. Ozonium root rot
    - c. Demotophora root rot
    - d. Root rot by pythium and phytophthora
    - e. Collar rot
4. Bacterial diseases
    - a. Blight
    - b. Crown gall
5. Virus and virus like diseases
    - a. Pierce's disease
    - b. Fan leaf
    - c. Yellow mosaic
    - d. Yellow vein
    - e. Leaf roll

C. Diseases of brambles and other small fruit (causes, symptoms, damage, and control)

1. Fungus diseases
    - a. Anthracnose
    - b. Cane blight
    - c. Cane and leaf spot
    - d. Fruit molds
    - e. Oak fungus
    - f. Orange rust
    - g. Powdery mildew
    - h. Raspberry leaf rust
    - i. Spur blight
    - j. Verticillium wilt
2. Bacterial diseases
    - a. Crown gall
    - b. Blight
3. Virus diseases
    - a. Dwarf or rosette
    - b. Yellows
    - c. Mosaics

X. Insects, Nematodes, Other Pests

A. Insects and grape growing

1. Phylloxera
    - a. History
    - b. Life cycle
    - c. Spread
    - d. Damage
    - e. Control
    - f. Resistant root stocks
2. Grape leaf hopper
3. Grape leaf folder or roller
4. Western grape skeletonizer
5. False chinch bug
6. Grasshoppers
7. Grape mealy bug
8. Thrips
9. Consperse stink bug
10. Grape-berry moth
11. Mediterranean fruit fly
12. Drosophila
13. Cutworms
14. Grape mud beetle
15. Click beetle
16. Aphids
17. Cane or twig borers
18. Scale insects

B. Insects attacking strawberries, bush berries, and other small fruit

1. Chewing insects: identification, damage, and control
    - a. Grasshopper
    - b. Japanese beetle
    - c. Cutworms
    - d. Raspberry leaf sawfly
    - e. Currant borer
    - f. Orange tortrix
    - g. Raspberry cane maggot
    - h. Raspberry horntail
2. Sucking pests: identification, damage, and control
    - a. Aphid
    - b. Leaf hoppers
    - c. Spittlebugs
    - d. Mites
        - (1) Red spider mite
        - (2) Blackberry mite
3. Insects with rasping mouth parts: identification, damage and control; many thrips

C. Spider mites

1. General description
2. Damage and mode of infestation
3. Control measures
    - a. Kelthane
    - b. Demetox
    - c Trithion
    - d. Parathion
    - e. T. E. P. P.
    - f. Sulfur
4. Mites affecting bush berries
    - a. Red spider mite
    - b. Blackberry mite

5. Mites affecting grapes
    a. Pacific mite
    b. Willamette mite
    c. Grape rust mite
    d. Erineum mite

D. Nematodes
1. General description and damage
2. General control methods
3. Specific nematodes causing damage to small fruits
    a. Root knot nematode
    b. Root lesion nematode
    c. Dagger nematode
    d. Sting nematode
    e. Northern root knot nematode

E. Other pests
1. Birds
    a. Shotgun blasts or noise makers
    b. Scarecrows and devices which involve motion
    c. Use of captive predator birds
    d. Poison
2. Deer and rabbits
    a. Fencing
    b. Poison
    c. Traps
    d. Repellents and dogs
3. Gophers, moles, and other rodents
4. Trespassers

XI. Grape Growing: Special Problems

A. Training the young vine
1. Forming heads, or spur-pruned vines
    a. Planting and care the first summer
    b. First winter pruning
    c. Second summer treatment
    d. Second winter pruning
    e. Third summer treatment
    f. Completing the head
2. Forming cane-pruned vines
3. Forming cordon: pruned vines
4. Training grapevines on arbors and walls

B. Pruning
1. Purposes of pruning
2. Response to pruning and crop
3. Principles of pruning
4. Suckering
5. Systems of pruning
    a. Head pruning
    b. Cordon pruning
    c. Cane pruning
    d. Pruning grapevines on arbors

C. Thinning
1. Flower cluster thinning
2. Cluster thinning
3. Berry thinning

D. Girdling
1. Objectives
2. Methods

E. Application of growth regulators
1. 4-Chlorophenoxyacetic acid
2. Benzothiazol-2-Oxyacetic acid
3. Gibberellin

F. Supports for vines
1. Headtrained, spur-pruned vines
2. Cane pruned vines
3. American grapevines
4. Cordon pruned vines
5. Table grapes, cane pruned
6. Trellises
7. Arbors and pergolas
8. Machine harvested vines

G. Frost protection
1. Wind machines
2. Heaters
3. Water applications
4. Others

H. Harvesting
1. Wine grapes
    a. Sampling
    b. Criteria for harvesting
        (1) Sugar content
        (2) Balling-acid ratio
        (3) Acidity
        (4) pH
    c. Care in harvesting and handling
2. Table grapes
    a. Standards for maturity
    b. Harvesting, selecting clusters
        (1) Appearance of berries
        (2) Color and condition of cluster stems
        (3) Taste
        (4) Picking and trimming
    c. Packing
        (1) Place
        (2) Containers
        (3) Arrangement in containers
    d. Maintaining quality of harvested grape
        (1) Bruising

        - (2) Trimming
        - (3) Speed
        - (4) Precooling and shipping

- I. Raisins
  - 1. Types of grapes used
  - 2. Quality factors in raisins
    - a. Food value
    - b. Attractiveness
    - c. Seeds, stems, texture, etc.
  - 3. Picking and drying methods
    - a. Yields
    - b. Composition of mature grape and drying effects
      - (1) Moisture
      - (2) Acid
      - (3) Sugar
      - (4) Water insoluble materials
      - (5) Minerals
    - c. When to harvest
    - d. Paper trays
    - e. Turning the trays
    - f. Rolling the trays
  - 4. Handling raisins after drying
    - a. Curing
    - b. Storing
- J. Handling of table grapes after harvest
  - 1. Precooling
  - 2. Fumigation
    - a. Absorption of sulfur dioxide
    - b. Precautions
  - 3. Cold storage
    - a. Systems
    - b. Deterioration
    - c. Predicting decay
  - 4. Transportation

XII. Strawberry Production: Special Problems

- A. Planting and training systems
  - 1. Hill system
  - 2. Matted: row system
  - 3. Spaced row system
  - 4. Flat bed systems
- B. Frost protection
  - 1. Mulch, synthetic or straw
  - 2. V-shaped troughs
  - 3. Paper, muslin, cheesecloth
  - 4. Spray irrigation
  - 5. Heaters
  - 6. Wind machines
- C. Removal of blossoms
- D. Care and setting runners
- E. Pruning
- F. Harvesting and handling
  - 1. The problem—metabolic rate high
    - a. Temperature
    - b. Humidity
    - c. Fruit
      - (1) Removal of all decayed fruit from plant
      - (2) Put only sound fruit in basket
      - (3) Use fungicides in field and storage
      - (4) Rapid cooling as soon as possible after picking
  - 2. Harvesting
    - a. Supervision
    - b. Stage of ripeness to pick
    - c. Method of snapping fruit without breaking cap or bruising berry
    - d. Method of placing berry in crate
  - 3. Field handling and hauling
    - a. Shade
    - b. Temperatures
    - c. Humidity
    - d. Cooling
  - 4. Shipping
    - a. Cooling
    - b. Holding
    - c. Loading
    - d. Transportation

XIII. Bushberry Production: Special Problems

- A. Pruning
  - 1. At planting
  - 2. Annual pruning
  - 3. Trailing blackberries
    - a. Placement of canes on trellis
    - b. Location of fruit
    - c. Pruning systems
    - d. Removal or pruning
  - 4. Erect blackberries and dewberries
  - 5. Red raspberries
  - 6. Black and purple raspberries
  - 7. Currants and gooseberries
  - 8. Blueberries
- B. Trellis types
  - 1. Supporting posts
  - 2. Two-wire trellis
  - 3. Three-wire trellis
  - 4. Four-wire trellis
  - 5. Separate stake and wire hoop systems
- C. Harvesting

1. Supervision
2. Stage of ripeness to pick
3. Equipment
   a. Baskets and crates
   b. Shade sheds
   c. Carriers
   d. Pallets

D. Storage and shipping
1. Cooling and humidity control
2. Loading
3. Transportation

XIV. Miscellaneous Fruit and Berries: Special Problems
A. Cranberries
B. Lychees
C. Lingonberry
D. Elderberry
E. Wonderberry
F. Salal
G. Salmonberry

Suggested Laboratory Projects (48 hours)

1. Classify and judge small fruits. (3 hours)
2. Identify quality factors in soils for small fruit production. (3 hours)
3. Plan and lay out a vineyard and berry planting. (3 hours)
4. Propagate plants by cuttings. (3 hours)
5. Propagate plants by budding, grafting, layering. (3 hours)
6. Plant and set out new stock. (3 hours)
7. Experiment with root depth and efficiency of irrigation. (3 hours)
8. Take field trip, observe soil conservation practices. (3 hours)
9. Measure pH in soils of various plantings; measure effects of buffers. (3 hours)
10. Identify and treat for diseases of strawberries and grapes. (3 hours)
11. Identify and treat for diseases and insects of bushberries. (3 hours)
12. Identify and treat for insects and pests of strawberries and grapes. (3 hours)
13. Prune and train grapes. (3 hours)
14. Plant strawberries. (3 hours)
15. Construct a trellis system for grapes and berries. (3 hours)
16. Prune and train bush berries. (3 hours)

Texts and References

DARROW, *Strawberry: History, Breeding, and Physiology*
SHOEMAKER, *Small Fruit Culture*
WINKLER, *General Viticulture*

Visual Aids

Arthur Barr Productions,
1029 North Allen Avenue,
Pasadena, Calif. 93271
Grapes, 16mm., color, 11 minutes

U.S. Department of Agriculture Motion Pictures Services, Washington, D.C. 20250
Raisins You Buy, 16mm., color, 5 minutes

Soil Management

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of those management principles and practices that are effective in maintaining soil in a highly productive condition. Laboratory assignment of experiments and demonstrations parallel lecture discussions as far as possible.

This course considers the effect of the various cultural operations upon the physical, chemical, and biological properties of the soil. Laboratory experiments and observations will emphasize proper soil conditions. Field study and observation will determine what the effect of the use of cultivation has been. Students will develop the ability to maintain soils in a productive state and learn methods of reclaiming those soils which have been damaged or are problem soils.

The community becomes the laboratory for the class. Farmers, soil conservation agencies, implement dealers, and fertilizer companies can provide useful information.

Major Divisions

		Class hours
I.	The Field of Soil Management	2
II.	Physical Makeup of Soils	2
III.	Soil Surveys and Land Layout	2
IV.	Nutrient Requirements of Plant Growth	2
V.	Fertilization Practices	6
VI.	Tillage	2
VII.	Soil and Water Relationships	2
VIII.	Use of Lime	2

IX.	Soil Protection Practices	4
X.	Soil Reclamation	6
XI.	Conservation Programs	2
	Total	32

Units of Instruction

- I. The Field of Soil Management
  - A. Serves both farmer and consumer
  - B. Importance
    - 1. Definition
    - 2. The agricultural revolution
    - 3. Soil management applied to farming
  - C. Rewards and dangers
    - 1. Improved standard of living
    - 2. Difficult for inefficient farmer to survive

- II. Physical Makeup of Soils
  - A. Origin
    - 1. Soil orders
    - 2. Materials and processes of soil development
      - a. Rock
      - b. Organic
      - c. Transported parent material
      - d. Soil profile
      - e. Factors describing soil: color, texture, structure
  - B. Great soil groups of the United States
    - 1. The pedalfers
    - 2. The pedocals

- III. Soil Surveys and Land Layout
  - A. Soil survey methods
    - 1. Inventory of the soil: a record of physical features
    - 2. Land capability classes
      - a. On basis of susceptibility to erosion
      - b. Climate, slope, erosion effects
      - c. Used to develop long range plans
  - B. Soil mapping units
    - 1. Effective depth, texture, permeability of subsoil
    - 2. Also included are available moisture capacity, reaction, drainage
  - C. Associated land features
    - 1. Slope
    - 2. Erosion
    - 3. Salinity
    - 4. Frequency of overflow
  - D. Mapping present land use
    - 1. Crop land
    - 2. Idle land
    - 3. Pasture land
    - 4. Woodland
    - 5. Brushland
  - E. Land capability classes
    - 1. Suited for cultivation
      - a. Class I: very good
      - b. Class II: moderate limitations
      - c. Class III: severe limitations in use
      - d. Class IV: very sever permanent limitation if used for cropland
    - 2. Unsuited for cultivation
      - a. Class V: kept in permanent vegetation
      - b. Class VI: grazing and forestry
      - c. Class VII: severe limitations when used for grazing and forestry
      - d. Class VIII: rough for woodland and grazing; best for recreation, wildlife
  - F. Effect of field size and shape
    - 1. Cultivation
    - 2. Irrigation
    - 3. Fencing

- IV. Nutrient Requirements of Plant Growth
  - A. Plant cells
  - B. Life processes of plants
  - C. Functions of roots
  - D. Functions of stems
  - E. Elements essential to plant growth
    - 1. From air and water
    - 2. From soil
    - 3. Microamounts
  - F. Colloidal clay, crystals
  - G. Organic soil colloids, humus
  - H. Cationic exchange
    - 1. Mechanism
    - 2. Measurement of soil fertility
  - I. Absorption and exchange of anions
  - J. Soil reaction: acidity and alkalinity
    - 1. Ionization
    - 2. Expressed as pH values
    - 3. Active and reserve acidity
    - 4. Buffering
    - 5. Soil reaction and plant growth
    - 6. Soil testing reaction
      - a. Dye methods
      - b. Electric pH meter
  - K. Importance of organic matter

- 1. Definition
- 2. Humus
- 3. Soil nitrogen content
- 4. Soil tilth

L. Maintaining and increasing organic matter
- 1. Grassland farming
- 2. Cropland farming
- 3. Carbon-nitrogen ratio
- 4. Compost

M. Buffer capacity of soils

N. Determining nutritional needs
- 1. Soil and plant tissue analysis
  - a. Reliability
  - b. Past experience
  - c. Specialized help
  - d. Other factors: weeds, diseases, insect pests
- 2. Tests for phosphorus
  - a. Several extracting solutions
  - b. Standard color chart comparison
- 3. Tests for K (potassium)
  - a. Exchangeable form
  - b. Standard color chart comparison
- 4. Tests for N (nitrogen)
  - a. Indicator solutions
  - b. Electrometric methods

O. Laboratory soil tests
- 1. Obtaining representative samples
  - a. Many locations in field
  - b. Remove surface litter
  - c. Recording soil samples
  - d. Prior history of use of field
- 2. Commercial testing laboratories
  - a. Testing methods
  - b. Interpreting tests
- 3. Soil testing kits
- 4. Hunger signs in crops

P. Fertilizer field trials
- 1. Most reliable
- 2. Accurately recorded
- 3. Residual effect

V. Fertilization Practices

A. Commercial fertilizers
- 1. Definition
- 2. Kinds and source
  - a. Nitrogen
  - b. Phosphate
  - c. Potash
  - d. Mixed
  - e. Effect upon soil
- 3. Economics
  - a. Crop requirements
  - b. Basis of purchase
  - c. Costs
- 4. Application
  - a. Forms
  - b. Methods
  - c. Placement
  - d. Time
  - e. Trends in mechanization
  - f. Effect of equipment
  - g. Relation to other operations

B. Animal manures
- 1. Analysis
  - a. Nutrient
  - b. Organic matter
- 2. Methods of handling
- 3. Methods of applying
- 4. Fortification
- 5. Conservation and storage
- 6. Costs

C. Green manure and cover crops
- 1. Value to the soil
- 2. Species and varieties
- 3. Cultural operations
  - a. Season of planting
  - b. Limitations
- 4. Costs

D. Soil amendments
- 1. Kinds
- 2. Value

VI. Tillage

A. Objectives
- 1. Weed control
- 2. Seedbed preparation
- 3. Planting
- 4. Facilitates
  - a. Water intake
  - b. Air movement
- 5. Incorporating crop residues and manures

B. Tillage equipment and its functions
- 1. Moldboard plows
- 2. Disk plows
- 3. Disk tiller or one-ways
- 4. Disk harrows
- 5. Rotary tillers
- 6. Spring-tooth harrows
- 7. Spike-tooth harrows
- 8. Cultipackers

9. Rod weeders
10. Blade or shovel tillers
11. Subsurface tillers

C. Effect on the soil
  1. Compaction
  2. Water penetration
  3. Root growth
  4. When to cultivate

D. Combination with other operations
  1. Planting
  2. Fertilization

VII. Soil and Water Relationships

A. Water relations
  1. Soil types and water entry
  2. Soil water movement and storage
    a. Adhesion
    b. Cohesion
  3. Classification of soil water
    a. Hygroscopic
    b. Capillary
    c. Gravitational
  4. Amount of water held in soils
  5. Determining soil moisture content
    a. Tensiometer
    b. Electrical conductivity
    c. Gravimetric

B. Soil moisture and crop growth
  1. Water as a nutrient
  2. Water as a solvent of plant foods
  3. Water as a plant constituent
  4. Transpiration
    a. Amount
    b. Factors affecting

C. Irrigation
  1. Water
    a. Crop requirement
    b. Availability
    c. Quality
    d. Cost
  2. Soil
    a. Texture
    b. Slope
    c. Penetration
    d. Plowsole
  3. Methods of application
    a. Flooding
    b. Furrow
    c. Sprinklers
    d. Subirrigation
  4. Combination with fertilizers
  5. Frost protection
  6. Effect on soil
    a. Leaching
    b. Erosion
    c. Waterlogging

VIII. Use of Lime

A. Need

B. Materials
  1. Quicklime
  2. Hydrated lime
  3. Limestone
  4. Byproducts

C. Calcium equivalents of lime materials
  1. Calculating
  2. Quality

D. Timing

E. Methods of application

F. Amount applied
  1. Determined by
    a. Soil acidity
    b. Buffer capacity
    c. Subsoil acidity
    d. Crops
    e. Purity of materials
  2. Overliming
    a. Amounts
    b. Symptoms

G. Relationship to other nutrients

IX. Soil Protection Practices

A. Managing wastelands
  1. Check gullies
    a. Dams
    b. Seeded with grass or trees
    c. Rodent control
    d. Fire protection
  2. Recreational facilities
    a. Birds
    b. Mammals
  3. Tree farming
    a. Shelter belts, woodlots
    b. Contour planting
    c. Thinning
    d. Other dangers
    e. Returns

B. Rangelands
  1. Water control
    a. Gullies
    b. Ponds
    c. Dams

- 2. Management
    - a. Reseeding
    - b. Renovation
    - c. Fertilization
    - d. Weed and brush growth
    - e. Animal control
    - f. Wildlife
- C. Croplands
  - 1. Crop rotation
    - a. Value
    - b. Crops used
    - c. Sequence
    - d. Time
  - 2. Terracing
    - a. Design
    - b. Construction
    - c. Maintenance
    - d. Cost
  - 3. Tiling
    - a. Advantages
    - b. Cost (More detailed under X)
  - 4. Soil cover
    - a. Water penetration
    - b. Run off control
    - c. Wind erosion control
    - d. Organic matter
    - e. Weed control
  - 5. Managing problem soils
    - a. Hardpan
    - b. Plowpan
    - c. Arid
    - d. Leached
    - e. Eroded

X. Soil Reclamation

- A. Use of land
  - 1. Increased irrigation
  - 2. Fertilization
  - 3. Tillage
  - 4. Development of new agricultural areas
- B. Soil solutions
  - 1. Saline
  - 2. Alkaline
  - 3. Saline—alkaline
  - 4. Formation
  - 5. Crop injury
- C. Testing procedures
- D. Soil treatment
  - 1. Saline
    - a. Leaching
    - b. Cropping program
  - 2. Alkaline
    - a. Neutralize excess alkalinity
    - b. Replace sodium with calcium
    - c. Improve physical properties
    - d. Leaching
    - e. Cropping program
- E. Tiling
  - 1. Soil conditions
  - 2. Design
  - 3. Laying
  - 4. Outlets
  - 5. Use of pumps
  - 6. Surface water
  - 7. Ultimate disposal
  - 8. Maintenance
  - 9. Cost
  - 10. Cropping programs
  - 11. Governmental programs
- F. Eroded soils
  - 1. Control methods
  - 2. Cropping programs
- G. Nutrient deprived soils
  - 1. Determine nutrients
  - 2. Application of fertilizers
  - 3. Cropping programs

XI. Conservation Programs

- A. Historical
- B. Current
  - 1. Nationwide soil conservation districts
    - a. Federal and State aid
    - b. Organization of local agency
  - 2. Private organizations
    - a. Izaak Walton League
    - b. The Friends of The Land
    - c. National Association of Conservation Districts
    - d. National Reclamation Association
  - 3. Business concerns
    - a. Timber operators
    - b. Public utilities
    - c. Farm equipment manufacturers
  - 4. Newer concept of conservation
- C. Results
  - 1. Flood prevention
  - 2. Water
    - a. Irrigation
    - b. Domestic use
    - c. Recreation
    - d. Transportation
    - e. Industry

3. Increased usable land
4. Benefits to American citizens

Suggested Laboratory Projects (48 hours)

1. Locate sources and make use of information in the library on soil management. (3 hours)
2. Identify the physical properties of soils including texture, structure, and parent materials. (3 hours)
3. Map a farm layout with special reference to soil characteristics and use. (3 hours)
4. Initiate pot culture trials and lay out fertilizer test plots. (3 hours)
5. Identify fertilizers, their properties and use. (3 hours)
6. Operate tillage equipment and observe tillage practices. (3 hours)
7. Make an evaluation of the effect of soil conditions upon irrigation practices; test for soil moisture. (3 hours)
8. Make calculations on water measurement, rate of flow, application. (3 hours)
9. Determine the pH of a soil solution and study buffering effects. (3 hours)
10. Test soils for solutes. (3 hours)
11. Test plant tissue. (3 hours)
12. Summarize findings of pot culture studies and fertilizer plots. (3 hours)
13. Demonstrate effect of soil conditions upon erosion. (3 hours)
14. Make a field trip to observe commercial fertilizer application or to see local conservation practices. (3 hours)
15. Practice judging land. (3 hours)
16. Analyze and evaluate a farm soil management program. (3 hours)

Texts and References

BERGER, *Introductory Soils*
DONAHUE, *Our Soils and Their Management*
KNUTI *and* others, *Profitable Soil Management*
TISDALE *and* NELSON, *Soil Fertility and Fertilizers*

Visual Aids and Models

Phillips Petroleum Co., Bartlesville, Okla. 74003
On The Other Side of the Fence; 16mm., sound, color, 22 minutes
Soil Conservation Service, Regional Office, Fort Worth, Tex.; Lincoln, Nebr.; Portland, Oreg.; and Upper Darby, Pa.
For A Permanent Agriculture; 16 mm., sound, color, 12 minutes
Raindrops and Soil Erosion; 16 mm., sound, color, 13½ minutes
Sterling Movies, U.S.A., Inc., 43 West 61st Street, New York, N.Y. 10023
Soil, 16mm., sound, 30 minutes
Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
Conservation of Natural Resources; 16mm., sound, black and white, 11 minutes
Look To The Land; 16mm., sound, black and write, 21 minutes
Our Soil Resources; 16mm., sound, black and white, 11 minutes
Yours Is The Land; 16mm., sound, color, 21 minutes
Nasco, Fort Atkinson, Wis. 53538
Soil and Conservation Kit (Model)

Soil Science

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the physical and chemical properties of soils as influenced by climate, the parent material from which they were formed, topography of the area, organisms in the soil, and time. The laboratory period includes map reading, moisture determinations, chemical analysis and study of approved soil practices in the area.

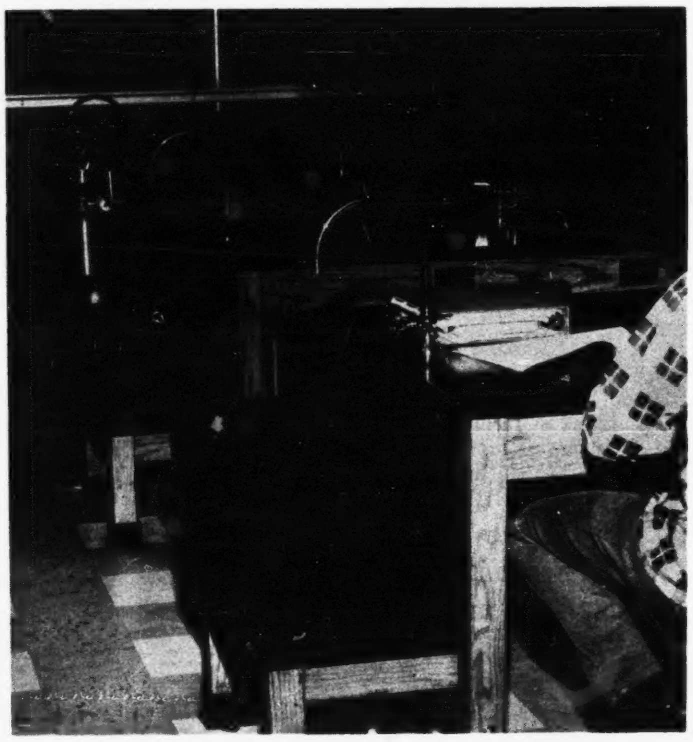

Figure 18.—A well-equipped soil laboratory must have acid-resistant sinks and safety equipment such as the eye washing fountain shown in the background.

This course is a systematic introductory study of soil science in the lecture and related laboratory periods. It is designed to present the basic principles of physical characteristics, chemical properties, the life in the soil, soil water and nutrition. Lectures should be supplemented from time to time by demonstrations of specific principles, motion pictures, and models. In addition to teaching the underlying principles of soil, the instructor should stress the scientific attitude by constantly weighing new findings in terms of past experiences.

The laboratory periods enable the student to conduct elementary experiments on the important phases of the living soil. Sessions are included on physical properties, chemical properties, and organic matter, coordinated with the lectures. Soil surveys, organic matter, and water also are considered. By performing actual experiments in the laboratory the student will acquire, with the instructor's help, a facility for handling laboratory equipment, some knowledge of laboratory methods and the basic facts of soil science.

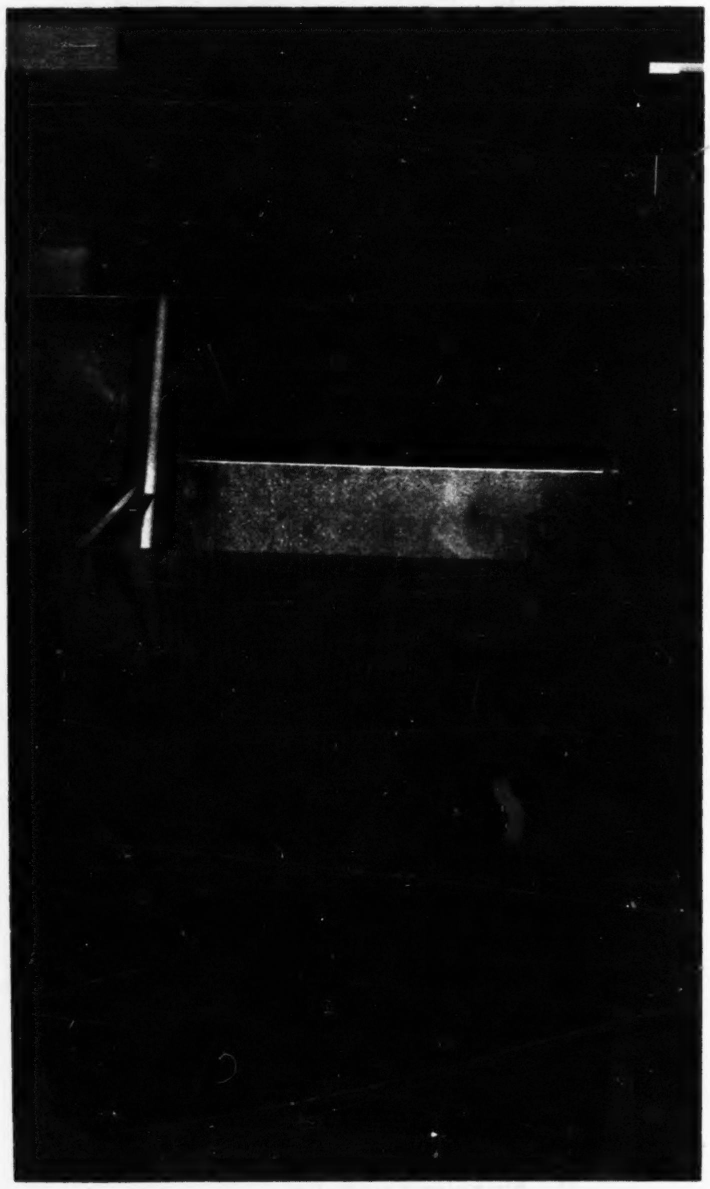

Figure 19.—This portable soil storage bin was designed to fit under the work table along the wall of the laboratory where it is out of sight, but where the soil can be kept in good condition and can be easily available when needed for study.

Major Divisions

		Class hours
I.	Physical Properties of Soils	2
II.	Parent Materials of Soils	2
III.	Soil Formation and Classification	2
IV.	Soil Surveys and Their Use	2
V.	Chemical and Colloidal Properties	2
VI.	Life In the Soil	2
VII.	Soil Organic Matter	2
VIII.	Soil Water	2
IX.	Plant Nutrition	2
X.	Lime and Liming	2
XI.	Fertilizers and Their Characteristics	2
XII.	Tillage	2
XIII.	Water Conservation	2
XIV.	Soil Conservation	2
XV.	Irrigation Practices	2
XVI.	Drainage Systems, Soil and Plant Diagnosis	2
	Total	32

Units of Instruction

I. Physical Properties of Soils
   A. Mechanical analyses
      1. Pipette methods
      2. Bouyoucos method
   B. Soil separates
      1. Size range
      2. Soil texture
      3. Soil structure
   C. Organic soils
      1. Peat
      2. Muck
   D. Particle density
      1. Definition
      2. Average
   E. Bulk density
      1. Definition
      2. Pore space
      3. Formula

- F. Soil consistence
  - 1. Wet
  - 2. Dry
- G. Soil color
  - 1. Hue
  - 2. Value
  - 3. Chroma

II. Parent Materials of Soils
- A. Residual material
  - 1. Igneous
  - 2. Sedimentary
  - 3. Metamorphic
- B. Transported material
  - 1. Water
    - a. Alluvial
    - b. Lacustrine
    - c. Marine
  - 2. Wind
    - a. Eolian
    - b. Loess
  - 3. Ice
    - a. Moraine
    - b. Till plain
    - c. Outwash plain
- C. Cumulose material
  - 1. Peat
  - 2. Muck
- D. Physical weathering
  - 1. Freezing, thawing
  - 2. Heating, cooling
  - 3. Wetting, drying
  - 4. Erosion
  - 5. Action of plants, animals, man
- E. Chemical weathering and chemical decomposition
  - 1. Carbonation
  - 2. Hydration
  - 3. Hydrolysis
  - 4. Solution
  - 5. Reduction
  - 6. Oxidation

III. Soil Formation and Classification
- A. Climate
- B. Parent material
- C. Relief
- D. Biosphere
- E. Time
- F. Soil groups
  - 1. Zonal
  - 2. Intrazonal soils
  - 3. Azonal soils

IV. Soil Surveys and Their Use
- A. Use
- B. National cooperative soil survey
- C. Legend: series, types, phases
- D. Soil profile
- E. Soil survey report
- F. Land capability classification

V. Chemical and Colloidal Properties
- A. Colloidal clay
- B. Soil colloids
- C. Cationic exchange
- D. Exchange capacity
- E. Absorption and exchange of anions
- F. Soil pH
- G. Buffer capacity
- H. Fixation of elements

VI. Life In the Soil
- A. Microflora and soil structure
- B. Plant roots
- C. Soil mammals
- D. Earthworms
- E. Arthropods; gastropods
- F. Protozoa; nematodes
- G. Distribution of microflora

VII. Soil Organic Matter
- A. Functions
- B. Chemical properties
- C. Biological properties
- D. Maintenance in humid regions
- E. Maintenance in semiarid regions

VIII. Soil Water
- A. Functions
- B. Infiltration
- C. Percolation
- D. Permeability
- E. Soil water classified
- F. Measuring soil moisture
- G. Leaching losses

IX. Plant Nutrition
- A. Essential elements
- B. Nutrient uptake
- C. Foliar nutrition
- D. Plant nutrition and soil physical conditions

X. Lime and Liming
  A. Its consumption
  B. Cause of soil acidity
  C. What lime does in soil
  D. Crop response to lime
  E. Liming materials
  F. Chemical guarantees
  G. Physical guarantees
  H. Crop lime requirement
  I. Nutrient availability and pH
  J. Applying
  K. Overliming
  L. Lime loss from soil

XI. Fertilizers and Their Characteristics
  A. The industry
  B. Nitrogen materials
  C. Phosphorous materials
  D. Potassium materials
  E. Secondary materials
  F. Micronutrient elements
  G. Formulation of mixed fertilizers
  H. Basicity or acidity of fertilizers
  I. Nutrients removed by crops
  J. Time of application
  K. Placement
  L. Profit from use

XII. Tillage
  A. Tillage and plant growth
  B. Chiseling
  C. Insect control
  D. Tillage and organic matter
  D. Tillage and organic matter
  E. Soil moisture and tillage
  F. Pan formation
  G. Tillage pans and infiltration rates
  H. Soil structure and cropping systems

XIII. Water Conservation
  A. Hydrologic cycle
    1. Surface runoff
    2. Leaching
    3. Evaporation
    4. Plant use
  B. Precipitation
  C. Runoff
  D. Water storage in soil
  E. Water storage in ponds
  F. Water storage in ground water
  G. Terracing
  H. Contour tillage

XIV. Soil Conservation
  A. Water erosion
    1. Splash
    2. Surface flow
    3. Channelized flow
  B. Water erosion is selective
  C. Topsoil depth versus crop yield
  D. Soil conservation districts
  E. Preferred cropping systems
  F. Terraces for erosion control
  G. Wind erosion

XV. Irrigation Practices
  A. Defined
  B. Soils of arid, semiarid regions
  C. Reclamation of saline, alkaline soils
  D. Salt tolerance of crops
  E. Water quality
  F. Crop consumptive use
  G. Soil water-holding capacity
  H. Irrigation depth for crops
  I. Frequency of irrigation
  J. Increasing infiltration rate of soils

XVI. Drainage Systems, Soil and Plant Diagnosis
  A. Benefits of drainage
  B. Soils requiring drainage
  C. Drainage capacity
  D. Methods of drainage
    1. Surface
    2. Tile
  E. Representative soil sample for testing
  F. Soil testing
  G. Tissue testing
  H. Deficiency symptoms
  I. Correcting deficiencies

Suggested Laboratory Projects (48 hours)

1. Find minerals and rocks important in soil formation. (3 hours)
2. Make a mechanical analysis of soil by the Bouyoucos method. (3 hours)
3. Classify soils. (3 hours)
4. Study soil surveys: initiate pot cultures. (3 hours)
5. Analyze soil properties related to texture. (3 hours)

6. Make field study of local soils or initiate a laboratory study of soil life. (3 hours)
7. Determine soil moisture by gravimetric, tensiometer, and electronic methods. (3 hours)
8. Ascertain organic matter and humus content of soil. (3 hours)
9. Determine pH of several samples of soil. (3 hours)
10. Learn lime characteristics; find estimated lime needs of crops. (3 hours)
11. Determine the cost relationship and economics of fertilizer use. (3 hours)
12. Measure plant decomposition; determine pot culture results. (3 hours)
13. Find out the advantages of reinforced barnyard manure. (3 hours)
14. 1. Make a field trip to a local soil conservation district; (3 hours) or
    2. Study practical conservation methods in the laboratory.
15. Determine the temperature relationship of soils. (3 hours)
16. Analyze soil and determine plant needs. (3 hours)

Texts and References

ARCHER, *Soil Conservation*
BERGER, *Introductory Soils*
BUCKMAN *and* BRADY, *Nature and Properties of Soils*
CHAPMAN *and* PRATT, *Methods of Analysis for Soils, Plants, and Waters*
DONAHUE, *Soils: An Introduction To Soils and Plant Growth*
MILLAR *and* others, *Fundamentals of Soil Science*
TISDALE *and* NELSON, *Soil Fertility and Fertilizers*

Visual Aids

Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
Face of The Earth, 16mm., sound, color, 12 minutes
Geological Work of Ice, 16mm., sound, color, 11 minutes
Ground Water, 16mm., sound, color, 11 minutes
The Work of Rivers, 16mm., sound, black and white, 11 minutes

National Plant Food Institute, Film Department, 1700 K Street N.W., Washington, D.C. 20006
The Big Test, 16mm., sound, color, 15½ minutes

Soil Conservation Service, Regional Offices: Fort Worth, Tex.; Lincoln, Nebr.; Portland, Ore.; or Upper Darby, Pa.
Birth of the Soil, 16mm., sound, color, 11 minutes
Erosion, 16mm., sound, 10 minutes

Union Pacific Railroad, Motion Picture Division, 1416 Dodge Street, Omaha, Nebr. 68102
Gift From The Clouds, 16mm., sound, color, 26 minutes
It's Time To Irrigate, 16mm., sound, color, 10 minutes

Charts and Pictures:
Ward's Natural Science Establishment, Inc., Post Office Box 1712, Rochester, N.Y. 14603
1 set of pictures of soils

Models:
Ward's Natural Science Establishment, Inc., Post Office Box 1712, Rochester, N.Y. 14603
1 set Soil Formation Collection
1 set Soil Types Collection
1 set Earth Science Mineral and Rock Collection

Nasco, Fort Atkinson, Wis. 53538
1 set Soil Separates
1 set Soil Formation Display
1 set Soil Classes
1 set Fertilizer Samples
1 Residual Soil Collection
1 Nasco Rock Collection

Subtropical Fruit Production

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the production of subtropical fruits, including avocados, citrus, dates, and olives. A study of the fundamental information relating to the commercial orchard management of these fruits. The laboratory work parallels the lectures with emphasis on the various cultural practices.

In the first part of the course the instructor reviews environment, nutrition, and propagation as they relate to subtropical fruit production. A brief consideration is given to pruning principles, cultivation and noncultivation methods, pest control and frost protection. Emphasis should be given to rootstocks and varieties of citrus, avocados, olives, and dates. A brief synopsis is given in the lectures of miscellaneous subtropical fruits. Harvesting and marketing are also covered.

The laboratory section offers practical work in the various aspects of production by on-the-job training in cultivation, fertilizers, pruning, and propagation. The instructor will demonstrate, then have students practice the skills enough to develop the required proficiency in subjects such as grafting in plant propagation. While presenting the basic principles in the laboratory, the instructor should illustrate them with the latest methods for doing the tasks in the industry at the current time.

Major Divisions

		Class hours
I.	Soil, Climate, Water	2
II.	Irrigation, Fertilization Practices	2
III.	Propagation: Seed Planting, Nursery Management, Plant Growth Regulators	2
IV.	Pruning, Cultivation Methods	2
V.	Mechanical, Biological Pest Control	2
VI.	Diseases	2
VII.	Frost Protection	2
VIII.	Citrus Rootstocks and Varieties	4
IX.	Avocado Rootstocks and Varieties	4
X.	Olive, Date, Fig	2
XI.	Miscellaneous Subtropical Fruits	2
XII.	Harvesting and Marketing	4
XIII.	Mechanization and Automation	2
	Total	32

Units of Instruction

- I. Soil, climate, Water
  - A. Soils
    - 1. Adaptation, types
    - 2. Water tables
    - 3. Salinity content
    - 4. Nutrients
  - B. Climate
    - 1. Temperature
      - a. High
      - b. Low
    - 2. Humidity
    - 3. Wind
      - a. Prevailing
      - b. Strength
  - C. Water
    - 1. Quantity
    - 2. Quality
      - a. Salinity content
      - b. Salt accumulation
      - c. Plow-sole elimination

- II. Irrigation, Fertilization Practices
  - A. Irrigation
    - 1. Most important factor
    - 2. Soils vary in water holding capacity
      - a. Sand
      - b. Clay
      - c. Loams
    - 3. Fundamentals
      - a. Saturation
      - b. Water holding capacity
      - c. Permanent wilting point
      - d. Available moisture
      - e. Evaporation
    - 4. Methods
      - a. Furrows
      - b. Sprinklers
      - c. Basins
    - 5. Measurement of water
  - B. Fertilization
    - 1. Nutrition
    - 2. Major elements: N (nitrogen), P (phosphorus), K (potassium)
    - 3. Microelements
    - 4. Deficiency symptoms
    - 5. Time of application
    - 6. Method of application
      - a. Broadcast
      - b. Irrigation water
      - c. Sprays
      - d. Systemics
    - 7. Sources of nutrients
      - a. Organic
      - b. Inorganic
    - 8. Requirements of tree
    - 9. Effects on fruit quality
    - 10. pH of soils
    - 11. Soil analysis
    - 12. Leaf (tissue) analysis
    - 13. Cost per unit

- III. Propagation: Seed Planting, Nursery Management, Plant Growth Regulators
  - A. Propagation
    - 1. Own-root trees
      - a. Growing seedlings
      - b. Cuttings
      - c. Layers
    - 2. Graftage
      - a. Rootstock
      - b. Scion
      - c. Advantages
      - d. Disadvantages
      - e. Methods
      - f. Cleft
      - g. Whip and tongue

- h. Whip graft
- i. Side graft
- j. Inarching
- k. Top working

3. Budding
    - a. Form of grafting
    - b. Advantages, disadvantages
    - c. Methods
        - (1) "T" or shield
        - (2) Inverted "T"
        - (3) Patch
4. Grafting waxes
5. Effects of stock and scion
6. Intermediate piece or "sandwich"
7. Care after grafting

B. Nursery management
    1. Layout
    2. Labor use
    3. Operations
        - a. Cultivation, weed control
        - b. Irrigation
        - c. Propagation
        - d. Harvesting
        - e. Ball and burlap
        - f. Seed planting
    4. Timing

C. Plant growth regulators
    1. Rooting of cuttings
    2. Hormones to aid fruit set
    3. Cut mature fruit drop
    4. Increasing fruit sizes
    5. Increasing storage life of fruit
    6. Chemical production of new varieties
    7. Chemicals used—concentrations

IV. Pruning, Cultivation Methods

A. Pruning
    1. Fruiting habits of trees
    2. Age of trees
        - a. Mature
        - b. Young trees
    3. Care in pruning; proper cuts
    4. Care after pruning; tree paint

B. Cultivation
    1. To control weed growth
    2. Plow-sole danger

C. Noncultivation
    1. Weed control by herbicides
    2. Improved water penetration
    3. Erosion minimized
    4. Organic mulchers

V. Mechanical, Biological Pest Control

A. Mechanical
    1. Fumigation; caution
    2. Oil sprays
    3. Equipment
    4. Timing
    5. New materials
    6. Soil fumigants
    7. The pests: scales, mites, worms, mealy bugs, beetles, snails
    8. Laws; regulations

B. Biological
    1. Cottony cushion scale; historical (Vedalia lady bird beetle)
    2. Present status of introduced parasites
    3. Ant control

VI. Diseases

A. Citrus
    1. Brown rot gummosis
    2. Brown rot
    3. Decline and collapse
    4. Scaly bark (virus)
    5. Shell bark (lemons)
    6. Quick decline
    7. Water spot of navels
    8. Oak root fungus
    9. Septoria rot

B. Avocados
    1. Dieback
    2. Root knot nematode
    3. Trunk canker
    4. Root rot
    5. Zinc deficiency

C. Olive
    1. Bacterial knot
    2. Verticillium wilt

D. Fig
    1. Fusarium wilt
    2. Sooty mold
    3. Souring

VII. Frost Protection

A. Temperature

B. Freezing injury
    1. How freezing kills
    2. Cause of frost resistance
    3. Surface influences
    3. Atmospheric conditions and damage
    5. Orchard site

C. Frost control

        1. Wind machines
        2. Orchard heaters
        3. Combination of above
        4. Blowers
        5. Flooding
    - D. Specific fruits
        1. Critical temperatures
        2. Treatment of trees after frost

VIII. Citrus Rootstocks and Varieties
- A. General considerations
- B. Lemon
    1. Rootstocks
        - a. Sour orange
        - b. Sweet orange
        - c. Rough lemon
        - d. Cleopatra mandarin
        - e. Sampson tangelo
        - f. Certain citranges
    2. Varieties
        - a. Eureka
        - b. Lisbon
        - c. Villafranca
        - Meyer lemon-dwarf
- C. Orange
    1. Sour orange; root stock
    2. Sweet orange
        - a. Rootstocks
            - (1) Sour orange
            - (2) Sweet orange
            - (3) Rough lemon
            - (4) Sweet lime
            - (5) Grapefruit
            - (6) Cleopatra mandarin
            - (7) Trifoliate orange
            - (8) Sampson tangelo
            - (9) Citranges
        - b. Varieties
            - (1) Washington navel
            - (2) Valencia
            - (3) Hamlin
            - (4) Parson Brown
            - (5) Pineapple
            - (6) Homosassa
            - (7) Jaffa
- D. Limes
    1. Rootstocks
    2. Varieties
- E. Grapefruit
    1. Rootstocks
    2. Varieties
- F. Mandarin oranges
- G. Orange hybrids

IX. Avocado Rootstocks and Varieties
- A. Rootstocks
    1. Mexican
    2. Guatemalan
    3. West Indian
- B. Varieties
    1. Fuerte
    2. Lula
    3. Hass
    4. Ryan
    5. Anaheim
    6. Dickinson
    7. Pollock
    8. Fuchsia

X. Olive, Date, Fig
- A. Olive
    1. General considerations
    2. Varieties
        - a. Mission
        - b. Manzanillo
        - c. Sevillano
        - d. Ascolano
- B. Date
    1. The tree, environment
    2. Flowers and fruit setting
    3. Mature fruit
    4. Varieties
        - a. Deglet Noor
        - b. Halawy
        - c. Khadrawy
        - d. Maktoom, Kustawy
- C. Fig
    1. General consideration
    2. Flowers, fruit setting
    3. Mature fruit
    4. Varieties
        - a. Mission
        - b. Calimyrna
        - c. Brown turkey

XI. Miscellaneous Subtropical Fruits
- A. Papaya
- B. Cherimoya
- C. Common guava
- D. Feijoa
- E. Sapodilla

- F. Loquat
- G. Mango
- H. Macadamia
- I. Banana

XII. Harvesting and Marketing
- A. Harvesting
  - 1. Maturity
  - 2. Standards by law
  - 3. Methods of harvesting
- B. Marketing
  - 1. Independent
  - 2. Cooperatives
  - 3. Direct
  - 4. Integrated

XIII. Mechanization and Automation
- A. Labor
  - 1. Primary factor
  - 2. Accelerated by economic factors
  - 3. Process advances
    - a. Labor assistance equipment
    - b. Partial labor replacement equipment
    - c. Complete labor replacement equipment
  - 4. Operations
    - a. Preparation
    - b. Planting
    - c. Pruning
    - d. Harvesting
    - e. Packing
    - f. Sales and transportation
- B. Time-Motion (efficiency) studies
  - 1. Problem
  - 2. Steps
  - 3. Possible solutions
  - 4. Application of best one
  - 5. Cost accounting and data processing

Suggested Laboratory Projects (48 hours)

1. Make soil analyses. (3 hours)
2. Irrigation methods, soil moisture determination. 3 hours)
3. Lay out fertilizer plots and problems. (3 hours)
4. Do nursery and orchard layout, management, and seeding. (3 hours)
5. Evaluate plant growth regulators. (3 hours)
6. Prune and sucker citrus and avocado trees. (3 hours)
7. Apply chemical pest control. (3 hours)
8. Take a field trip to insectary. (3 hours)
9. Practice disease identification and control. (3 hours)
10. Operate orchard heaters and wind machines. (3 hours)
11. Practice grafting citrus trees. (3 hours)
12. Practice grafting avocado trees. (3 hours)
13. Study mechanization, packing plant design, cultivation, and non-cultivation. (3 hours)
14. Practice budding avocados trees. (3 hours)
15. Practice budding citrus trees. (3 hours)
16. Take a field trip to central market or byproducts plant or fruit packing plant. (3 hours)

Texts and References

ANDUS, *Plant Growth Substances*
CHANDLER, *Evergreen Orchards*
KLOTZ, *Color Handbook of Citrus Diseases*
LEOPOLD, *Plant Growth and Development*
MORTENSEN *and* BULLARD, *Handbook of Tropical and Subtropical Horticulture*
SINCLAIR, *The Orange: Its Biochemistry and Physiology*

Truck Crops

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of the vegetable industry and the problems involved in truck crops production. Laboratory periods will include practical experience in the cultural operations of growing vegetable crops.

The instructor should spend most of the lecture time on the specific practices of the vegetables of major economic significance to the local area. Emphasis should be placed upon those aspects of production which enhance both yields and market quality. Students will be given periodic reading assignments in current literature to keep them abreast with current trends.

Laboratory periods will provide students with opportunities to apply those principles of production emphasized in the lecture. The school farm will be utilized to demonstrate the various cultural practices and to provide plant materials for classroom study.

Students will have an opportunity to conduct various demonstration projects on the school farm.

Major Divisions

	Class hours
I. Introduction to Classifications of Vegetables	2
II. Geographic Production Areas	2
III. Soils and Climatic Regions	2
IV. Seeds and Seed Propagation	2
V. Cultural Practices: Irrigation	2
VI. Cultural Practices: Fertilization	2
VII. Cultural Practices: Insects and Pests	2
VIII. Cultural Practices: Disease Control	2
IX. Food Values	2
X. Cool Season Crops	6
XI. Warm Season Crops	6
XII. Marketing	2
Total	32

Units of Instruction

- I. Introduction to Classifications of Vegetables
  - A. History and types of truck crop production
  - B. History and method of botanical classification
    - 1. Flower parts
    - 2. Latin terminology
  - C. Other methods of classification
    - 1. Part eaten
    - 2. Number of seasons plant may live
    - 3. Optimum growing temperatures (thermo classification)
      - a. Cool season crops
        - (1) Those intolerant of freezing
        - (2) Those tolerant of freezing
      - b. Warm season crops
    - 4. Cultural methods

- II. Geographic Production Areas
  - A. California
    - 1. Central valleys
    - 2. Salinas Valley
    - 3. Imperial Valley
  - B. Western States
    - 1. Arizona
    - 2. Idaho
    - 3. Colorado
    - 4. Washington, Oregon
    - 5. Utah, Montana
    - 6. New Mexico, Nevada, Wyoming
  - C. Mexico
  - D. Midwest
  - E. East
  - F. South, including Florida
  - G. Foreign
    - 1. Western Europe
    - 2. Russia
    - 3. Far East
    - 4. South America

- III. Soils and Climatic Regions
  - A. Introduction to Soils
    - 1. Types and characteristics; stress pH
    - 2. Function and importance
    - 3. Desirable characteristics of vegetable soils
    - 4. Selection of vegetables to meet various soil characteristics
    - 5. Cultural practices to develop more desirable vegetable soils
    - 6. Organic matter
  - B. Climatic factors and their effect
    - 1. Temperature
    - 2. Precipitation
    - 3. Photo period
    - 4. Smog
    - 5. Wind
  - C. Erosion control

- IV. Seeds and Seed Propagation
  - A. Seeds
    - 1. Dicots
    - 2. Monocots
    - 3. Factors affecting viability
    - 4. Anatomy
    - 5. Germination; stress moisture and temperature
    - 6. Coating and seed treatment
  - B. Seed production
    - 1. Requirements and problems
    - 2. Areas of production
    - 3. Inheritance and production of hybrids
  - C. Propagation of seeds
    - 1. Field methods
    - 2. Flat, cold frame, hot beds, etc.
    - 3. Planting rates
    - 4. Planting dates
    - 5. Planting depths
  - D. Hardening and transplanting
  - E. Propagation by asexual means
    - 1. Bulbs
    - 2. Tubers
    - 3. Runners, division, etc.

V. Cultural Practices: Irrigation
A. Introduction to plant moisture
1. Field capacity
2. Moisture equivalent
3. Permanent wilting percentage
B. Moisture requirements and various rooting depths by crops
C. Methods of irrigation; stress planning
1. Furrow or surface
a. Slope
b. Length of run
2. Sprinkler
3. Subirrigation
D. Water quality

VI. Cultural Practices: Fertilization
A. Introduction to primary nutrients
1. N (Nitrogen)
2. P (Phosphorous)
3. K (Potassium)
B. Minor elements and mixed fertilizers
C. Quantity to use
D. Methods of application
1. Broadcasting
2. Bands
3. Top dressing
4. Irrigation water
E. Manure and organic matter
F. Soil amendments to change pH or improve water penetration
1. Lime
2. Gypsum
3. Sulfur
4. Certain fertilizer
G. Suggested rotations

VII. Cultural Practices: Insects and Pests
A. Important vegetable insects (characteristics, primary food, control)
1. Cutworms
2. Blister beetles
3. Wireworms
4. Aphid
5. European corn borer
6. Japanese beetle
7. Tomato hornworm
B. Important vegetable pests (characteristics, primary food, control)
1. Nematodes
2. Mites
3. Gophers
4. Rabbits
5. Slugs and snails
C. Weed control
1. Chemicals
2. Rotations
3. Cultivation practices

VIII. Cultural Practices: Disease Control
A. Introduction to vegetable diseases
1. Cost and importance
2. Damage
3. Micro-organisms causing disease
B. Important vegetable diseases (characteristics, important costs, control)
1. Crown gall
2. Damping off
3. Bacterial soft rot
4. Sclerotinia rot (cottony mold)
5. Rhizoctonia
6. Curly top
7. Fusarium wilt
8. Mosaic
9. Spotted and verticillium wilt

IX. Food Values
A. Introduction to nutrition
1. Nutrients and function
2. Minimum daily requirement
B. Composition of vegetables; stages of maturity
1. Leafy green
2. Yellow "fruit" vegetables
3. Root crops
4. Others
C. Processing and preparation; effect on food value
1. Canning
2. Cooking
3. Freezing
4. Drying
5. Aging

X. Cool Season Crops
A. Temperature adaptation
B. Crops
1. Major
a. Cabbage
b. Spinach
c. Broccoli
2. Minor crops
a. Beets, radish, turnip, parsnip

- b. Kale and collards
- c. Kohlrabi, brussels sprouts
- d. Rhubarb, watercress
- e. Horsebeans

C. Damage done by adverse weather

D. Cultural practices
  1. Planting
  2. Spacing
  3. Harvesting

E. Storage requirements

XI. Warm Season Crops
  A. Species and varieties involved
  B. Adaptation to temperatures
    1. Intolerant of frost
      a. Sweet corn
      b. Snap beans
      c. Lima bean
      d. Tomato
      e. Pepper
      f. Squash, pumpkin
      g. Cucumber
      h. Cantaloupe
    2. Require continuous warm weather
      a. Watermelon
      b. Sweet potato
      c. Eggplant, okra, hot peppers
  C. Damage done by adverse weather
  D. Cultural practices
    1. Propagation
    2. Planting
    3. Harvesting
  E. Storage requirements

XII. Marketing
  A. Transportation and cost analysis
  B. Preparation for marketing
    1. Grading
    2. Packaging
    3. Washing, etc.
  C. Field trip to central market

Suggested Laboratory Projects (48 hours)

1. Classify and identify vegetable crops. (3 hours)
2. Plan and lay out a field. (3 hours)
3. Propagate truck crop plants by seeds. (3 hours)
4. Propagate truck crop plants by methods other than seeds. (3 hours)
5. Transplant truck crop seedlings. (3 hours)
6. Thin an established stand of truck crop plants. (3 hours)
7. Study protective practices for young plants. (3 hours)
8. Study soil mulching. (3 hours)
9. Construct supporting structures for vegetables. (3 hours)
10. Study maturity indications, standards, and grades for vegetables. (3 hours)
11. Take a field trip to a truck farm; study harvesting methods and equipment. (3 hours)
12. Study nutritive value and chemical composition of vegetables. (3 hours)
13. Test and evaluate the quality of vegetable products. (3 hours)
14. Take a field trip to a vegetable processing plant. (3 hours)
15. Study preservation and processing of vegetable crops. (3 hours)
16. Take a field trip to a wholesale vegetable market. (3 hours)

Texts and References

JONES *and* MANN, *Onions and Their Allies*
KNOTT, *Handbook for Vegetable Growers*
MACGILLIVRAY, *Vegetable Production*
MACGILLIVRAY *and* STEVENS, *Agricultural Labor and Its Effective Use*
THOMPSON *and* KELLEY, *Vegetable Crops*
WHITAKER *and* DAVIS, *Cucurbits*
U.S. Department of Agriculture Bulletins
  Commercial Growing of Sweet Corn, Farmers' Bulletin No. 2042
  Lettuce and Its Production, Agriculture Handbook No. 221
  Muskmellon Culture, Agriculture Handbook No. 216
  Commercial Growing of Carrots, Leaflet No. 353
  Fresh Cabbage, Marketing Bulletin No. 2
  Commercial Production of Tomatoes, Farmers' Bulletin No. 2045
  Cauliflower and Broccoli—Varieties and Culture, Farmers' Bulletin No. 1957

Weeds and Weed Control

Hours Required

Class, 2; Laboratory, 3.

Course Description

A study of identification, growth characteristics, and control of those weeds detrimental to cultivated crops and grasslands. During the laboratory period students will learn to identi-

Figure 20.—Weed control courses for farm crop production technicians include a study of equipment, techniques, and scientific use of cultivating and weed controlling machinery such as the cultivator shown here in a soybean field.

fy the important species of weeds and to make applications of herbicides.

During class discussions students will be able to familiarize themselves with the physiological response of weeds to the various control treatments. Integration of chemical and cultural procedures into an effective weed control program will be stressed. Special attention will be given to characteristics, formulations, and safe application of the various herbicides.

In the laboratory students will learn to recognize the various weed species by observing their habitats, studying herbarium specimens and by making herbarium collections. They will also have an opportunity to gain experience in calibrating spray rigs and in applying herbicides. Students will be required to maintain notebooks on the phytotoxic properties of the herbicides which they have applied.

Term projects are assigned requiring each student to select a local farm and to outline and complete a weed control program for the cropped and noncropped areas of the farm.

Major Divisions

		Class hours
I.	Importance of Weeds	2
II.	Reproduction of Weeds	3
III.	Characteristics of the Weedy Species	2
IV.	Cultural and Biological Control of Weeds	6
V.	General Principles of Chemical Weed Control	5
VI.	Safe Handling of Herbicidal Materials	2
VII.	Selective Herbicides	3
VIII.	Nonselective Herbicides	3
IX.	Control of Weeds in Specific Crops	3
X.	Application Methods and Equipment	3
	Total	32

Units of Instruction

I. Importance of Weeds
  A. Definition of a weed
  B. Economic losses resulting from weeds
    1. Cost of weeds
    2. Types of loss
      a. Increased costs of production
      b. Reduction in yields
      c. Reduction in quality of crops and crop products
      d. Reduction in quality of animal products
      e. Loss of animals due to poisonous plants
      f. Detrimental to human health
      g. Clogging of waterways and irrigation ditches
      h. Undermining of roadways and structures
      i. Detracts from aesthetic value of landscape
      j. Fire hazards
      k. Harbor pests and plant diseases
    3. Losses in agricultural areas
      a. Grain crops
      b. Field crops
      c. Forage crops
      d. Vegetable crops
      e. Orchards
      f. Vineyards
  C. Beneficial aspects of weeds
    1. Soil indicators
      a. Soil pH
      b. Soil fertility
      c. Soil drainage
    2. Provide feed for livestock
    3. Soil and water conservation
    4. Food and cover for wildlife

II. Reproduction of Weeds
  A. Reproduction by seed
    1. Seed structures, spread by wind
      a. Saccate fruits
      b. Parachute fruits
      c. Comate fruits
      d. Winged fruits
      e. Plumed fruits
    2. Seed structures, spread by mechanical means
      a. Fleshy fruits
      b. Sticky seeds
      c. Rough seed coat
      d. Floating seeds
      e. Bristles, burs, thorns
      f. Gelatinous seeds
    3. Plant structures contributing to spread
      a. Tumbling weeds
      b. Shooting seed pods
    4. Disseminating agents of seed
      a. Farm tillage and harvesting equipment
      b. Adulterated crop seed
      c. Adulterated crop products
      d. Animal feed
      e. Screenings
      f. Farm livestock
      g. Adulterated horticultural products
      h. Water
      i. Fill dirt
    5. Germination
      a. Conditions influencing germination
      b. Dormancy, natural
      c. Dormancy, induced
      d. Dormancy, role of inhibitors
    6. Effect of various treatments upon the viability of seed
      a. Harvesting when immature
      b. Storage
      c. Herbicidal treatment
      d. Burning
      e. Submerging in water
      f. Burying in soil
      g. Ensiling
      h. Passage through animals
      i. Grinding
  B. Vegetative reproduction
    1. Type of root systems
    2. Size of root system
    3. Root cuttings
    4. Stolons
    5. Regrowth capacity of perennials

III. Characteristics of the Weedy Species
  A. Grow and reproduce under marginal conditions
    1. Soil
    2. Climate
    3. Short growing seasons
  B. Ability to reproduce by seed
    1. Production of large numbers of seed
    2. Effective dissemination of seed
    3. Dormancy of seed
    4. Longevity of seed
  C. Ability to propagate vegetatively
    1. Naturally
    2. Under cultivated conditions
    3. Regrowth after loss of foliation
  D. Repel grazing
    1. Unpalatable
    2. Rapid recovery
  E. Resistant to weed chemicals
  F. Competitive growth with other plants

IV. Cultural and Biological Control of Weeds
  A. Hoeing
  B. Tillage
    1. Principles of control
      a. Fallowing
      b. Clean tilled crops
      c. Rotations of tilled and nontilled crops
    2. Frequency of tillage
    3. Relationship to other cultural practices
    4. Effect on perennials
    5. Costs of tillage
    6. Tillage equipment
      a. Plows, harrows, discs
      b. Duckfoot cultivators
      c. Rotary hoes and thinner-weeders
      d. Rod weeder
    7. Combining with chemical weed control
  C. Mowing
    1. Areas of use
    2. Relationship to soil conservation
    3. Effect on the growth habits of weeds
    4. Combining with other cultural practices
  D. Flooding
    1. Principles of control

2. Effect on growth and development of weeds
3. Effect on weed seed
4. Effect on soil

E. Flaming
  1. Principles of flaming
    a. Heat tolerant plants
    b. Regrowth of treated plants
    c. Length of flaming time
    d. Temperature of flame
  2. Effect on crop plants
  3. Methods of flaming
    a. Parallel flaming
    b. Cross flaming
  4. Flaming equipment
  5. Calibrating pressure settings and speed of travel
  6. Nonselective flaming
  7. Selective flaming
    a. Crops
    b. Effects on yield and quality
  8. Costs

F. Smothering
  1. Principles of smothering
  2. Materials used
  3. Crops on which this method can be used

G. Competitive crops
  1. Principles in growing competitive crops
  2. Crops grown competitively
    a. Forage crops
    b. Cereal crops
    c. Large seeded legumes
  3. Characteristics of competing plants
    a. Ready and uniform germination
    b. Rapid development of an extensive foliar area
    c. Large number of stomata
    d. Early development of an extensive root system
    e. Primary and secondary roots
  4. Effect of competition on crops
    a. Yield
    b. Quality
  5. Crop rotations
  6. Combining with other control methods

H. Biological control of weeds
  1. Definition of biological control
  2. Conditions necessary for success using insects
    a. Highly specialized feeders
    b. Limited to a specific habitat
    c. Limited to host plant only
    d. Introduced free of predators and diseases
    e. Not subjected to new predators
  3. Attaining an equilibrium
  4. Species controlled biologically
    a. Prickly pear
    b. Klamath weed
    c. Lantana
    d. Nutgrass
    e. Puncture vine
    f. Gorse
    g. Wild blackberry
    h. Tansy ragwort
  5. Relationship to cultural practices

V. General Principles of Chemical Weed Control

A. Definitions
  1. Selective herbicides
  2. Nonselective herbicides
  3. Root applications
  4. Foliar applications
  5. Preemergence applications
  6. Postemergence applications
  7. Contact herbicides
  8. Translocated herbicides
  9. Carrier
  10. Solvent
  11. Toxicant
  12. Filming agent
  13. Wetting agent
  14. Emulsion
  15. Invert emulsion
  16. Acute toxicity
  17. Chronic toxicity

B. Plant processes and their relationship to herbicides
  1. Photosynthesis
  2. Respiration
  3. Production of enzymes, hormones, etc.
  4. Cell division, elongation, differentiation
  5. Transpiration
  6. Translocation of water and food
  7. Synthesis and storage of food
  8. Reproduction (vegetative and sexual)
  9. Turgor
  10. Abcission

- C. Penetration and translocation
  - 1. Stomatal absorption
  - 2. Cuticular penetration
  - 3. Xylem translocation
  - 4. Phloem translocation
  - 5. Intercellular translocation
- D. Factors affecting the effectiveness of chemicals
  - 1. Plant species
    - a. Stage of growth
    - b. Growth habits
    - c. Morphological characters
    - d. Plant microenvironment
    - e. Physiological characteristics
  - 2. Characteristics of the herbicide
    - a. Formulation
    - b. Concentration
    - c. Volatilization
    - d. Spreading ability
  - 3. Mechanics of application
    - a. Complete coverage
    - b. Size and density of particles
    - c. Combinations with other materials
- E. Surfactants
  - 1. Definition
  - 2. Types of surfactants
    - a. Anionic
    - b. Cationic
    - c. Nonionic
    - d. Amphoteric
  - 3. Selecting the proper surfactant
    - a. Concentration and type
    - b. Herbicide
    - c. Plant species
    - d. Cost

VI. Safe Handling of Herbicidal Materials

- A. Personal safety devices
  - 1. Protective clothing
  - 2. Protective mechanical devices
- B. Safe practices
  - 1. Skin care
  - 2. Care of clothing
  - 3. First aid
  - 4. Storage of injurious materials
  - 5. Labeling
  - 6. Decontamination of equipment
  - 7. Neutralization and disposal of unused materials
  - 8. Disposal of empty containers
  - 9. Mixing chemicals
  - 10. Understanding the toxicological properties of herbicides
  - 11. Personnel education
- C. Applications of herbicides
  - 1. Climatic conditions
  - 2. Timing applications
  - 3. Avoiding drift
  - 4. Food crops
  - 5. Toxicity of herbicides to livestock and wildlife
- D. Residues in crops
  - 1. Safe tolerances
  - 2. Cumulative effect
  - 3. Carryover effect
- E. Laws relating to herbicides
  - 1. Legal tolerances
  - 2. Personnel safety
  - 3. Damage to neighboring crops
  - 4. Purchasing and applying herbicides

VII. Selective Herbicides

- A. Principles of selectivity
  - 1. Differential wetting
    - a. Waxy leaf surfaces
    - b. Corrugated leaf surfaces
    - c. Foliar area
    - d. Position and arrangement of leaves
  - 2. Location of growing parts
  - 3. Difference in plant tolerances
  - 4. Selective herbicidal placement
  - 5. Differences in growth habits
    - a. Dormancy
    - b. Deep rooted crops
    - c. Perennial crops
    - d. Habitat differences
    - e. Stage of growth
- B. Factors affecting selectivity
  - 1. Type of crop
  - 2. Botanical characteristics of the weed species
  - 3. Environmental conditions
  - 4. Concentration and dosage of herbicide
  - 5. Formulation of herbicide
  - 6. Retention of herbicide by the soil
  - 7. Size and age of weed species
  - 8. Metabolic condition of plant
- C. Selective-foliar contact herbicides
  - 1. Types of herbicides
    - a. Dinitrophenols
    - b. Metal organic salts
    - c. Selective oils

        2. Modes of action
    D. Selective-translocated foliar applications
        1. Types of herbicides
            a. Hormone-like compounds
            b. Carbamates
            c. Arsenicals
        2. Modes of action
        3. Advantages and limitations
    E. Selective herbicides: root applications
        1. Types of herbicides
            a. Substituted areas
            b. Phenoxy compounds
            c. Carbamates
            d. Aliphatic acids
            e. Simazine and triazine compounds
            f. Dinitrophenols
        2. Modes of action
        3. Selectivity and soil retention of herbicides
        4. Advantages and limitations

VIII. Nonselective Herbicides
    A. Foliar applications
        1. Areas of use
        2. Types of herbicides
            a. Water soluble chemicals
            b. Oils
            c. Oil-water emulsions
            d. Chlorinated benzenes and aromatic solvents
            e. Quaternary ammonium compounds
        3. Modes of action
        4. Preemergence applications
        5. Advantages and limitations of nonselectives
    B. Translocated foliar applications
        1. Factors affecting translocation
            a. Time of application
            b. Soil moisture
            c. Concentration of herbicide
            d. Rainfall
            e. Temperature
        2. Types of herbicides
            a. Arsenicals
            b. Chlorate compounds
            c. Acidified copper sulfate
            d. Thiocyanates
        3. Modes of action
    C. Root applications, temporary soil sterilants
        1. Volatile chemicals
            a. Types of materials
            b. Modes of action
            c. Factors affecting movement in soil
            d. Season of application
            e. Effect on soil
            f. Methods of applying
            g. Response of weeds
            h. Secondary benefits
        2. Other materials
            a. Types of chemicals
            b. Modes of action
            c. Effects on the soil
            d. Timing the application
            e. Methods of applying
    D. Root applications, long lasting sterilants
        1. Areas of use
        2. Types of materials
            a. Chlorate compounds
            b. Boron compounds
            c. Arsenicals
            d. Substituted ureas
            e. Heterocyclic nitrogen derivatives
        3. Movement in the soil
        4. Factors affecting longevity
            a. Soil moisture
            b. Soil temperature
            c. Soil type
            d. Concentration and dosage of herbicide
            e. Weed species
            f. Fertility and pH of soil
            g. Photodecomposition
            h. Microbiological activity
        5. Advantages and limitations of soil sterilants

IX. Control of Weeds in Specific Crops (Rates of Application, Timing the Application, Methods of Applying, Precautions in Applying)
    A. Forage and cereal crops
        1. DNBP
        2. 2, 4D
        3. IPC
        4. Dalapon
        5. CIPC
        6. Diuron
        7. EPTC
        8. Barban
        9. MCPA
        10. Atrazine
        11. Proponil

    12. Trifluralin
  - B. Field crops
    1. EPTC
    2. 2, 4D
    3. Monuron
    4. Diuron
    5. Dalapon
    6. CIPC
    7. Endothal
    8. PEBC
    9. MCPA
    10. IPC
  - C. Vegetable crops
    1. CDEC
    2. 2, 4D
    3. Selective oils
    4. Dalapon
    5. EPTC
    6. Atrazine
    7. CIPC
    8. IPC
    9. KOCN
    10. PEBC
  - D. Orchard and vineyard crops
    1. Simazine
    2. Monuron
    3. Diuron
    4. Weed Oils

X. Application Methods and Equipment
  - A. Requirements of application equipment
    1. Applies material at a controllable rate
    2. Applies material evenly
    3. Rate can be predetermined
  - B. Spraying
    1. Types of sprayers
       - a. Large ground rigs
       - b. Aircraft sprayers
       - c. Logarithmic sprayers
    2. Pumps
       - a. Gear
       - b. Centrifugal
       - c. Impeller
       - d. Diaphragm
       - e. Piston
    3. Power supply
       - a. Power takeoff
       - b. Self contained
       - c. Traction wheel drive
    4. Strainers
    5. Booms
    6. Pressure regulators
    7. Nozzles
       - a. Spray patterns
       - b. Size
    8. Hoses
    9. Agitators
       - a. Mechanical stirring
       - b. Hydraulic
    10. Preventing drift
       - a. Timing the application
       - b. Thickened sprays
       - c. Nozzle size
       - d. Pressure regulation
  - C. Soil injection equipment
  - D. Dusting
    1. Advantages
    2. Disadvantages
  - E. Granular materials
    1. Methods of applying
       - a. Broadcasting
       - b. Banding
    2. Application equipment
       - a. Broadcasters and drills
       - b. Soil incorporating
    3. Advantages
    4. Disadvantages
  - F. Calibrating equipment
  - G. Decontamination of equipment
    1. Materials toxic to plants
       - a. Water soluble materials
       - b. Insoluble materials
       - c. Hormone-like materials
    2. Materials toxic to man
    3. Corrosive materials

Suggested Laboratory Projects (48 hours)

1. Study the morphological characteristics and key the various weed families. (6 hours)
2. Survey the weed control problems of the local farm community. (3 hours)
3. Apply soil sterilants to selected weed control plots. (3 hours)
4. Apply selective and nonselective herbicides to selected weed control plots. (3 hours)
5. Identify the noxious weeds and weed seeds. (3 hours)
6. Study weed control equipment. (3 hours)
7. Calibrate spray rigs. (3 hours)
8. Study and observe herbicidal applications. (3 hours)

9. Collect, identify, and make herbarium mounts of the important species of weeds. (21 hours)

Texts and References

Crafts, *The Chemistry and Mode of Action of Herbicides*
Crafts *and* Robbins, *Weed Control*
Klingman, *Weed Control: As A Science*
U.S. Department of Agriculture, *Summary of Registered Pesticide Chemical Uses*

Auxiliary and Supporting Technical Courses

Agricultural Mechanics

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the basic mechanical concepts used on a modern farm. Safety and good work habits are emphasized. Blueprint reading, sketching and drafting, carpentry, concrete, welding, hot and cold metal, plumbing, painting, and electrical work are the subjects of study. The laboratory will include practical application and use of the skills associated with the studies.

The course is designed to give students knowledge, understanding, and application of the tools and materials in everyday work around the farm. Students will be involved in planning, sketching, drafting, print reading, material and cost estimating for the various mechanical requirements on a modern farm. The study includes selection, construction, operation, maintenance, and repair of buildings, structures, equipment, and machines and methods used for better farm operation. The tools, materials, and equipment needed to accomplish the work in the particular subject must be understood and skill developed in their use and selection.

Students will study welding to learn the procedure and methods, since there will be little time to develop skill in welding. They may use additional practice to develop some skill when time is available during other laboratory activities.

Students will have the opportunity to put their ideas and knowledge to practical use with laboratory work. They will construct and repair projects that are used on the modern farm.

Major Divisions

	Class hours
I. Shop Rules, Procedures, and Safety Practices	2
II. Sketching, Drafting, Blueprint Reading	6
III. Building and Carpentry	4
IV. Concrete	2
V. Welding	6
VI. Metalwork	5
VII. Plumbing	1
VIII. Protection of Machinery and Buildings	2
IX. Electricity	4
Total	32

Units of Instruction

I. Shop Rules, Procedures, and Safety Practices
  A. Safety
  B. Operation of equipment and power tools in shop
    1. Woodworking
    2. Metalworking

II. Sketching, Drafting, Blueprint Reading
  A. Lines
    1. Alphabet of lines
    2. The working drawing
    3. Views
  B. Dimensions
  C. Sketching
    1. Making a working sketch
    2. Sketching shapes
    3. Projections
  D. Reading and applying blueprints
    1. Abbreviations and symbols
    2. Detail and assembly prints

III. Building and Carpentry
  A. Shop layout
  B. Bill of materials
  C. Cost estimating
  D. Tool identification, use, care

IV. Concrete
  A. Ingredients
    1. Material selecting
    2. Silt testing

    - 3. Water
    - 4. Proportions
- B. Form construction and reenforcing concrete
- C. Determining quantities of materials
    - 1. Self-mixed
    - 2. Ready-mixed
- D. Placing and finishing
    - 1. In forms
    - 2. In slabs
- E. Curing
    - 1. Moisture
    - 2. Effect of weather
    - 3. Form removal
    - 4. Watertight concrete

V. Welding
- A. Metallurgy
    - 1. Structure of metal
    - 2. Effect of welding
    - 3. Properties of metal
    - 4. Classifications of metals
- B. Machines, supplies, and accessories for electric arc welding
    - 1. Terms
    - 2. AC-DC equipment
    - 3. Personal needs
    - 4. Shop requirements
    - 5. Electrodes and welding rods
- C. Electric arc welding
    - 1. Four essentials of arc welding
    - 2. Fusion welding
    - 3. The crater
    - 4. Electrode patterns
    - 5. Types of welds
    - 6. Position welding
    - 7. Safety
- D. Machines, supplies, and accessories for oxyacetylene welding
    - 1. Oxy-acetylene cylinders
    - 2. Regulators
    - 3. Hoses, connections
    - 4. The torch
- E. Oxy-acetylene welding
    - 1. Preparing to weld
        - a. Setting up the units
        - b. Testing for leaks
        - c. Selecting the correct tip
    - 2. Lighting and operating the torch
        - a. Welding tip
        - b. Cutting tip
    - 3. Flame control
        - 1. Flame characteristics
        - 2. Controlling backfire and flashback
        - 3. Shutting off the torch
    - 4. Running a bead
    - 5. Position welding
    - 6. Safety
- F. Drafting and drawing for welding and welding symbols

VI. Metalwork
- A. Sheet metal
    - 1. Soldering
    - 2. Folding and forming
- B. Cold metal
    - 1. Identifying metals
    - 2. Cutting and filing
    - 3. Drilling, tapping, threading
- C. Hot metal
    - 1. Blacksmithing
    - 2. Welding

VII. Plumbing
- A. Pipe fitting
    - 1. Cutting and measuring pipe
    - 2. Installation
- B. Copper, plastic, and other

VIII. Protection of Machinery and Buildings
- A. Painting
- B. Glazing
- C. Protecting surfaces
    - 1. Coatings
    - 2. Plastics
    - 3. Storage

IX. Electricity
- A. What it is; how it works
    - 1. Sources of electricity
    - 2. Work a nonelectrician can do
    - 3. Electrical terms
    - 4. Materials used
- B. Circuits
    - 1. Planning the wiring system
    - 2. Calculating loads
    - 3. Methods of wiring
        - (a) wiring fundamentals
        - (b) splices and connections
    - 4. Maintaining the system
        - (a) Repairs to wire
        - (b) Repairs to fixtures

C. Electric motors
  1. Selecting the motor
    (a) size and mounting
    (b) types
  2. Installing the motor
  3. Maintaining the motor

Suggested Laboratory Projects (48 hours)

1. Take a field trip to a local farm; visit shop and storage facilities. Note arrangement of tools, power equipment, storage and work areas; check for safety practices. (This trip can be used for information to draw shop plans) (3 hours)
2. Introduce students to facilities. Tour the shop, demonstrating operation of equipment, safety rules, and practices in their use. Show placement, care and safe operation of hand and portable tools. Give a safety test written and practical. (3 hours)
3. Have students do complete plates including printing, sketching, and drawing. Beginning use of drafting machines. (3 hours)
4. From blueprints or drawings have students make bills of material, order lists and estimate cost of construction for a project; or construct a project drawn by student such as sawhorses, gate, feed trough. (3 hours)
5. Do a concrete job by mixing, pouring, testing, and calculating materials. (3 hours)
6. Construct some useful project from sheet metal, such as a guard for a pulley, bolt or pipe carrier; or repair a damaged sheet metal part from a piece of machinery. (3 hours)
7. Demonstrate and have students practice assembling oxyacetylene equipment, lighting and adjusting the flame, running a bead, and cutting techniques. Have students practice cutting and welding in various positions according to individual ability. (3 hours)
8. Demonstrate methods of metal identification, operation of electric arc machines, striking an arc, and running a bead. Have students practice welding in the various positions according to individual ability (6 hours)
9. Demonstrate and have students practice special methods and applications such as welding, alloys and castings, hardfacing, brazing, and controlling distortion. (3 hours)
10. Have students cut, file, fit, drill, and tap a metal block. Students should then cut threads on a round stock to fit the tapped hole, shaping an eye on the other end of the round stock. They should hotcut and form metal on the anvil. Projects might include making a screwdriver or cold chisel and heat treat or harden it. (3 hours)
11. Do plumbing projects; include cutting, reaming, and threading metal pipe, silver soldering a copper fitting or joint, and making a pvc plastic joint. 3 hours)
12. Take a field trip to a paint dealer or manufacturer for paint quality evaluation demonstration of application methods and methods of paint selection. (3 hours)
13. Draw an electric circuit, hook up a short distance unit, and measure currents. (6 hours)
14. Test and service electric motors: single and three phase. (3 hours)

Texts and Reference

DAVIS, *Welding and Brazing*
FARRALL, *Engineering for Dairy and Food Products*
GIACHINO *and* others, *Welding Skills and Practices*
PARKER, *Farm Welding*
PHIPPS, *Mechanics in Agriculture*

Crop Marketing

Hours Required

Class, 3; Laboratory, 0.

Course Description

A course in the principles and practices of marketing crop products, emphasizing problems in distribution and normal channels of trade. Marketing problems for specific crops are included.

This course is designed to give students insight into the marketing process for fruits and other crops. The first part of the course deals with general aspects of marketing that would apply to all products but can be illustrated using examples with crops.

The course should be devoted to the main problems of the state in which it is taught, but should not be limited to these. The latter part of the course allows some time to discuss specific crops that are important locally.

Major Divisions

	Class hours
I. The Marketing Framework	12
II. Marketing Functions	18
III. Cooperative Marketing	6
IV. Marketing Various Crops	12
Total	48

Units of Instruction

- I. The Marketing Framework
  - A. The marketing problem
    - 1. Define marketing
    - 2. Historical development
    - 3. Characteristics of agricultural production
  - B. Consumers of agricultural products
    - 1. Distribution of people
    - 2. Effect of income
    - 3. Effect of population growth
    - 4. Regional differences
    - 5. Religious differences
    - 6. Foreign markets
  - C. Costs of marketing
    - 1. The market basket
    - 2. The farmer's share
    - 3. Marketing bill for various commodities
    - 4. Marketing costs: jobs
    - 5. Marketing costs: functions
    - 6. Methods of reducing costs

- II. Marketing Functions
  - A. The exchange function
    - 1. Supply
    - 2. Demand
    - 3. Elasticity
    - 4. Equilibrium
    - 5. Cost-price relationships
    - 6. Effects on prices
  - B. Risk bearing and futures
    - 1. Marketing risks
    - 2. The futures market
    - 3. Operation of the Board of Trade
    - 4. Futures contracts
    - 5. Speculators
    - 6. Commodities sold in futures trading
  - C. Transportation and storage
    - 1. Truck transportation
    - 2. Rail transportation
    - 3. Air transportation
    - 4. Freight rates
    - 5. Effects on prices
    - 6. Types of storage
    - 7. Commodities stored
    - 8. Storage costs
  - D. Wholesaling and retailing
    - 1. Types and sizes of wholesalers
    - 2. Changes in wholesaling structure
    - 3. Types of retailers
    - 4. Changes in retailing
    - 5. Vertical and horizontal integration
    - 6. Effects of chains
  - E. Standardization and grading
    - 1. Importance of standards and grades
    - 2. Development of standards and grades
    - 3. Determination
    - 4. Criteria for various crops
    - 5. Health regulations
  - F. Market news service
    - 1. Need for market news
    - 2. Development of market news service
    - 3. Collection of market information

- III. Cooperative Marketing
  - A. History and development
    - 1. Historical development
    - 2. Types of cooperatives defined
    - 3. Organization
  - B. Special characteristics
  - C. Operation and management
  - D. Laws affecting cooperatives
  - E. Agencies serving cooperatives

- IV. Marketing Various Crops
  - A. Grain marketing
    - 1. Effects of production
    - 2. Production areas
    - 3. Transportation
    - 4. Storage
    - 5. Country elevators
    - 6. Terminal markets
    - 7. Grading
    - 8. Futures market
    - 9. Government programs
  - B. Fruit and vegetable marketing
    - 1. Special problems
    - 2. Fresh v. processed
    - 3. Transportation and storage
    - 4. Production areas
    - 5. Exports and imports

C. Marketing cotton
  1. Marketing structure
  2. Production areas
  3. Grades and standards
  4. Byproducts
  5. Export market
  6. Marketing problems
  7. Government programs

D. Tobacco marketing
  1. Production areas
  2. Marketing methods
  3. Classification
  4. Government programs

Texts and References

DARRAH, *Food Marketing*
KOHLS, *Marketing of Agricultural Products*
THOMSEN, *Agricultural Marketing*
U.S. Department of Agriculture Yearbooks:
Consumers All 1965
Protecting Our Food 1966
Periodicals:
U.S. Department of Agriculture, *Agricultural Marketing*

Farm Machinery

Hours Required

Class, 1; Laboratory, 3.

Course Description

A course in the selection, operation, servicing, adjustment, and maintenance of farm machinery and equipment. The laboratory will include calibration, adjustment, and evaluation of performance of tillage, planting, weed control, harvesting and processing machinery.

Class discussions will give students knowledge needed for working with machinery and equipment in the laboratory. Students will learn the basic mechanics and theories of operation of farm machinery. They will obtain a knowledge of the basic machine types and classes and those factors governing the wise selection of machinery for various farm operations. They will learn to repair, adjust, operate, and evaluate the efficiency of farm machinery.

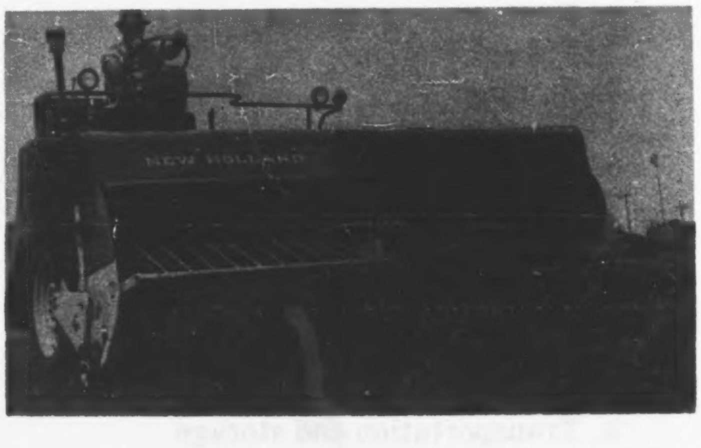

Figure 21.—A study of farm machinery must be a part of a farm crop production technology program. The producer of this forage crop must know how to operate and maintain the self-propelled hay-baler shown here, and he must also know when his crop has dried to the optimum moisture content for baling.

In the laboratory, study and testing will be done on the pulling forces required, hitching methods, and their effect on the machine. Methods of attaching and adjusting the machines for varying conditions of soil, topography, and plants will be studied and tested. Seeding equipment, fertilizer applicators, spray rigs, and dusters will be calibrated.

Emphasis is placed on safety while working with the machines. Students are expected to understand the selection, care, maintenance, proper storage, and operation of each piece of machinery.

Tests will be given throughout the course and reports made for each machine under study.

Major Divisions

		Class hours
I.	Shop Rules, Procedures, Safety Practices	1
II.	Development of Farm Machinery	1
III.	Primary Tillage	2
IV.	Secondary Tillage	2
V.	Planting and Seeding Machines	1
VI.	Fertilizing and Cultivating	2
VII.	Crop Protection	2
VIII.	Harvesting	4
IX.	Special Equipment	1
	Total	16

Units of Instruction

I. Shop Rules, Procedures, Safety Practices
  A. Review of shop procedures
  B. Review of shop safety considerations

II. Development of Farm Machinery
  A. History
    1. Need for machinery on a modern farm
    2. Mechanical progress
    3. Size determination
    4. Quantity's and quality's part in mechanical farming

        5. Machinery is a necessary part of production, not a service to production
    B. Selecting farm machinery
        1. Defining a machine
        2. Basic calculation
            a. Force, work, power
            b. Pulleys and gears
            c. Capacity of farm implement
    C. Company trade names and trademarks
        1. Define trade name and trademark
        2. Manufacturer differences
            a. Models
            b. Design
            c. Ease of operation
            d. Ease of maintenance, adjustment, and repairs
        3. Ability to do the work under varying conditions
        4. Operator control and comfort
        5. The machines' adaptability and maneuverability
        6. Safety
            a. Need
            b. How to use machinery safely

III. Primary Tillage
    A. Factors affecting primary tillage implements, selection and operation
    B. Purpose of tillage
    C. Methods of tillage
    D. Moldboard plow
        1. Parts of plow
        2. Types of bottoms
        3. Shares
        4. Materials of construction
        5. Coulter, jointers, and other attachments
    E. Disk plow
        1. Parts of plow
        2. Types of plows
        3. Design and operation principles
        4. Attachments
    F. Subsurface and speciality plows
        1. Rotary plows
        2. Chisels
        3. Subsoilers

IV. Secondary Tillage
    A. Disk harrows
        1. Types and parts
        2. Uses
        3. Parts and accessories
    B. Spike tooth and spring tooth harrows
        1. Types and operation
        2. Uses
    C. Land rollers and packers
        1. Types and operation
        2. Uses
    D. Subsurface tillage
        1. Types and operation
        2. Uses
    E. Specialty tillage implements
        1. Types and operation
        2. Uses

V. Planting and Seeding Machines
    A. Planting purpose, value, and requirements
    B. History
    C. Classification of planters, mounting, power requirements, feeding mechanism, soil opening mechanism covering devices, and accessories
        1. Broadcasters
        2. Drills
        3. Row crop planters
            a. Corn
            b. Cotton
            c. Vegetable
            d. Others
        4. Potato planters
        5. Transplanters
    D. Fertilizing attachments

VI. Fertilizing and Cultivating
    A. Manure spreader
        1. Construction
        2. Operation
        3. Maintenance
        4. Accessories
    B. Granular fertilizers
        1. Construction
        2. Operation
        3. Maintenance
        4. Accessories
    C. Liquid and gas fertilizers

VII. Crop Protection
    A. Spraying
        1. Purpose
        2. History
        3. Types
    B. Dusters

    1. Purpose
    2. History
    3. Types

VIII. Harvesting
  A. Hay harvesting
    1. Mowers
    2. Rakes
    3. Balers
  B. Row crop harvesting
    1. Forage harvesters
    2. Corn pickers
    3. Cotton pickers
    4. Combine
    5. Potato
    6. Vegetable
  C. Grain harvesting
    1. Combines
    2. Specialty items
  D. Fruit and nut harvesters
  E. Beet harvester
  F. Other specialized harvesters

IX. Special Equipment
  A. Processing equipment
    1. Crop residue disposal
    2. Rotary mowers
    3. Shellers
    4. Mills, hammer
    5. Grinders
  B. Feed mixers
  C. Crop and hay dryers
  D. Silage equipment
  E. Elevators, loaders, wagons, hoists, and other devices
  F. Cultivators
    1. Purpose
    2. History
    3. Mounting
    4. Shovels and sweeps
    5. Operation
  G. Rotary hoe
    1. Construction
    2. Operation
    3. Use
  H. Flame cultivation
    1. Construction
    2. Operations
    3. Use and limitations
  I. Chemical cultivation
    1. Preemergence application
    2. Postemergence application
      a. Construction
      b. Operation
      c. Use

Suggested Laboratory Projects (48 hours)

Note.—Select machines which are used in the area for special study.

1. Tour lab facilities; have students determine operating condition of machines; discuss maintenance and its relation to operation of a machine. Explain rules and regulation for work in the lab. (The evaluation section can be done with a field trip or on students' home farms. Emphasis on safety). (3 hours)
2. Give students practice in the selection of a machine for a given job. Include safety factors. (3 hours)
3. Study of hitching, pulling, and operations of plows and tillage. Set up a plow with strings showing pulling force lines. Test power requirements for pulling a plow. (3 hours)
4. Study of secondary tillage, evaluating work depth and efficiency in varying conditions, and testing power requirements. (3 hours)
5. Test accuracy and precision of planters with oil belt test in lab. (3 hours)
6. Calibrate a planting machine. (3 hours)
7. Set up and adjust a cultivator. (3 hours)
8. Calibrate a fertilizer applicator. (3 hours)
9. Calibrate a manure spreader. (3 hours)
10. Calibrate a spraying or dusting unit. (3 hours)
11. Set the register and lead on a mower. (3 hours)
12. Do an off-season renovation on a hay baler. (3 hours)
13. Set, adjust, and test a corn picker or cotton picker. (3 hours)
14. Set, adjust, and test a combine. (3 hours)
15. Set, adjust, and test a specialty harvester used locally. (3 hours)
16. Take a field trip to dealer for review and new developments. (3 hours)

Texts and References

HARRIS, *Farm Machinery*
HUNT, *Farm Power and Machinery Management*

Richey *and* others, *Agricultural Engineers' Handbook*
Shippen *and* Turner, *Basic Farm Machinery, Vol. II*
Smith, *Farm Machinery and Equipment*

Farm Management

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the selection, organization, and operation of the modern farm. The laboratory period provides time for observing and practicing farm operations and management.

This course emphasizes the basic economic and agricultural principles upon which the farm business is organized and operated.

Examples of farms with good and poor farming practices are used to emphasize the value of selection and planning. Enterprises are analyzed as to their adaptability and efficiency. Such problems as labor and mechanization are considered as they affect farm operation.

The laboratory period of the course in Farm Management can assume many patterns depending upon the community, the farm background of students, and facilities available. Class work should include "doing" activities as well as observation and evaluation of practices carried out in actual situations.

The suggested program makes use of classroom facilities, shop and outside areas, the farm, and related agricultural business agencies of the community. Many assignments may be completed on the college farm. Class assignments should be related to improving the efficiency and income of the farm.

Emphasis should be placed on farm costs, labor, material, and supplies. The value of maintenance should be stressed.

Major Divisions

		Class hours
I.	Field of Management	2
II.	Selection of a Farm	2
III.	Obtaining a Farm	4
IV.	Layout of a Farm	2
V.	Farm Resources	2
VI.	Enterprises	2
VII.	Labor and Mechanization	4
VIII.	Calendar of Operations	4
IX.	Reorganization of a Farm	2
X.	Farm Law and Codes	4
XI.	Economic Principles	4
	Total	32

Units of Instruction

- I. Field of Management
  - A. Definition
  - B. Need
    - 1. Changing conditions
    - 2. Labor
    - 3. Competition
    - 4. Mechanization
    - 5. Capital
    - 6. Increased expenses
  - C. Tools
    - 1. Records
    - 2. Reports
    - 3. Budgets
    - 4. Decisionmaking process
    - 5. Economic principles
  - D. Manager
    - 1. Ability
    - 2. Flexibility
    - 3. Responsibility
    - 4. Information

- II. Selection of a farm
  - A. Area
    - 1. Agriculture
    - 2. Trend
    - 3. Location
    - 4. Transportation
    - 5. Agri-services
    - 6. Place to live
  - B. Farm
    - 1. Enterprises
    - 2. Scope
    - 3. Condition
    - 4. Utilities
    - 5. Soil
    - 6. Water
    - 7. Topography
    - 8. History
    - 9. Production capacity
    - 10. Cost

- III. Obtaining a Farm
  - A. Ownership v. renting
    - 1. When to purchase
    - 2. When to rent
  - B. Ownership

1. Type
    a. Individual proprietor
    b. Partnership
    c. Corporation
2. Appraisal
3. Capital
4. Use of credit
    a. Source
    b. Time
    c. Rate
    d. Payments

C. Renting
1. Basis
2. Agreements
3. Opportunity to purchase

D. Contracting

IV. Layout of a Farm
A. Legal description
B. Acreage
C. Farmstead
1. Location
2. Utilities
3. Relation to fields
4. Buildings
5. Service area

D. Field
1. Topography
2. Soil
3. Shape
4. Accessibility
5. Fencing
6. Erosion

V. Farm Resources
A. Land
1. Amount
2. Use
3. Condition
4. Possibilities

B. Buildings
1. Kind
2. Condition
3. Adaptability

C. Stock
1. Kind
2. Amount

D. Equipment
1. Kind
2. Amount
3. Condition

E. Labor
1. Need
2. Available
    a. Hired
    b. Family

F. Management
1. Experience
2. Other sources

G. Operating capital
1. Amount
2. Availability
    a. Current
    b. Intermediate
    c. Long term

VI. Enterprises
A. Of area
1. Kind
2. Adaptability
3. Scope
4. Status

B. Relationship
1. Complementary
2. Supplementary
3. Joint product
4. Competitive
5. Antagonistic

C. Combinations
1. Scope
2. Income
3. Problems
4. Possibilities

D. Changes
1. Economic
2. Cultural

VII. Labor and Mechanization
A. Agricultural changes
1. Number of units
2. Size
3. Increased costs
4. Increased production
5. Specialization

B. Farm labor
1. Nature
2. Supply
3. Costs
4. Management
    a. Selection
    b. Work schedules
    c. Housing

    - d. Pay schedule
    - e. Incentives
  - 5. Work simplification
- C. Mechanization
  - 1. Trends
  - 2. Labor costs
  - 3. Capital investment
  - 4. Costs of operation
- D. Job instruction training
  - 1. Individual
  - 2. Group
- E. Other instructional programs

VIII. Calendar of Operations
- A. Crops
  - 1. Labor
  - 2. Machinery
  - 3. Land use
  - 4. Relation to livestock
    - a. Supply
    - b. When needed
  - 5. Programs
- B. Livestock
  - 1. Labor
  - 2. Machinery
  - 3. Relation to crops
    - a. Need
    - b. Supply
    - c. Cost

IX. Reorganization of a Farm
- A. Use of resources
  - 1. Capital
  - 2. Labor
  - 3. Management
- B. Efficiency
  - 1. Farm
  - 2. Related to area
- C. Risk and uncertainty
- D. Changes
  - 1. Enterprise
  - 2. Cultural
  - 3. Financial

X. Farm Law and Codes
- A. Responsibility
  - 1. Land
  - 2. Water and mineral
  - 3. Workman's Compensation
  - 4. Social Security
  - 5. Labor laws
- B. Contracts and agreements
- C. Agricultural codes
  - 1. Provisions
  - 2. Authority
  - 3. Compliance
- D. Use of legal advice

XI. Economic Principles
- A. Diminishing returns
- B. Substitution
- C. Opportunity cost
- D. Comparative cost
- E. Marginal utility

Suggested Laboratory Projects (48 hours)

1. Study the arrangement of farmstead facilities and farm areas using scaled model buildings. (3 hours)
2. Take a field trip to a local farm to study facilities and setups. Obtain breakdown of investment in various categories for future use. (3 hours)
3. Establish a legal description for the farm. (3 hours)
4. Analyze a farm to evaluate enterprises, cultural operations, and land utilization. (6 hours)
5. Analyze a farm to evaluate labor and machinery costs. (6 hours)
6. Practice filling out forms for loans, consideration of the appraisal process, security, and budgets. This assignment may be a cooperative effort with a bank or lending agency. (3 hours)
7. Study and practice job instruction training (6 hours)
8. Make time and motion studies on a farm. (3 hours)
9. Analyze and practice handling labor problems. (6 hours)
10. Have visit with agricultural inspector regarding inspection procedures and laws. (3 hours)
11. Evaluate a farm program in view of material considered during course. (3 hours)
12. Prepare a formal written report on a farm with commendations and/or recommendations to increase efficiency and income. (3 hours)

Texts and References

Bryant *and* Hamilton, *Profitable Farm Management*
Case *and* others, *Principles of Farm Management*
Castle *and* Becker, *Farm Business Management*
Chastain, Yaeger, *and* McGraw, *Farm Business Management*
Hall *and* Mortenson, *The Farm Management Handbook*
Hedges, *Farm Management Decisions*
MacGillivray *and* Stevens, *Agricultural Labor and Its Effective Use*
Roy, *Contract Farming U.S.A.*
Wallace *and* Benke, *Managing the Tenant-Operated Farm*

Farm Power

Hours Required

Class, 2; Laboratory, 3.

Course Description

An elementary course in the fundamental mechanical principles of engines and their components in order to supply power for the modern farm. The laboratory period includes testing, adjusting, maintenance, and study of engines and power transfer.

The course is designed to give students an understanding of how an engine works to convert energy to productive use, to give them the knowledge to evaluate, select, and use power units and their transmitting components. The course includes the study of internal combustion engine, power transmission, lubricants, fuel, hydraulics, bearings, and hitches.

The study will give students the ability to analyze reports on efficiency of power units and determine the need for, and type of, repairs and maintenance necessary to the equipment. They will learn how to best use and get the desired results from the various power units.

Students will be able to hitch and use tractor power units to the best advantage. They will study how to set up and use belt horsepower, drawbar horsepower, power-take-off horsepower, hydraulic horsepower, and the mechanical methods of applying tractor power. They will learn the parts of the tractor and their uses in the engine; why and how to carry on a proper maintenance program to increase life and efficiency of the power units. This includes an understanding of the internal workings and principles of the internal combustion engine as well as the tractor as a whole.

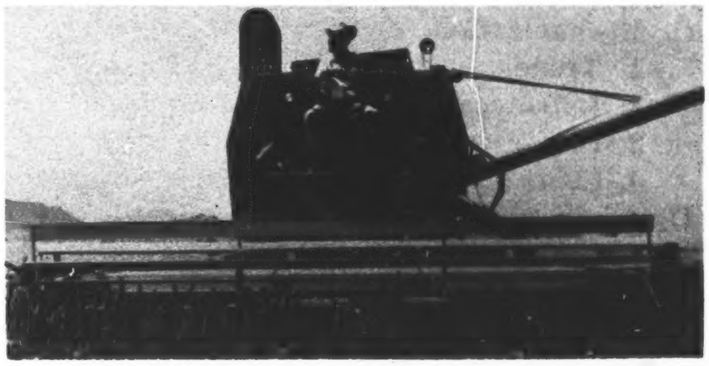

Figure 22.—Some of the most sophisticated agricultural production machinery is harvesting equipment, an example of which is shown here. This is a special harvester for cutting and threshing grain sorghum, an important crop in Texas, Kansas, and Oklahoma and many other States.

Major Divisions

		Class hours
I.	Shop Rules, Procedures, Safety Practices	1
II.	History and Development of Power Farming	1
III.	Mechanics and Power Calculations	2
IV.	Materials of Construction	1
V.	Nomenclature	1
VI.	Power Transmission	2
VII.	Hydraulics	2
VIII.	Lubrication, Lubricants, Fuels	4
IX.	Internal Combustion Engine	6
X.	The Tractor	8
XI.	Hitches and Power Measurement	2
XII.	Other Power Engines	2
	Total	32

Units of Instruction

I. Shop Rules, Procedures, Safety Practices

II. History and Development of Power Farming
- A. The purpose of power farming
- B. The growth of mechanical power
  - 1. Man and animal
  - 2. External combustion
  - 3. Internal combustion
  - 4. Today's and tomorrow's power sources
- C. History of farm power

III. Mechanics and Power Calculations
- A. Energy
  - 1. Mechanical energy
  - 2. Electrical energy
  - 3. Chemical energy
  - 4. Kinetic energy

    5. Potential energy
  B. Force, work, power
  C. Machines
    1. Simple machines
    2. Torque-speed
    3. Power efficiency

IV. Materials of Construction
  A. Need for different materials
    1. Stress and strain
    2. Characteristics of the materials
    3. Bonding methods
  B. Metals
    1. Ferrous
      a. Iron
      b. Steel
    2. Nonferrous metals
  C. Nonmetalic materials
    1. Plastic
    2. Rubber
    3. Wood
    4. Others
  D. Treatment and bonding of materials
    1. Special use (soft center steel)
    2. Hardening and finishing surfaces
    3. Bonding methods

V. Nomenclature
  A. Tools
  B. Engines
  C. Parts of machines

VI. Power Transmission
  A. Direct drive
  B. Clutches
  C. Gears
  D. Shafts and universal joints
  E. Pulleys and belts
  F. Chain and sprockets
  G. Flexible shaft
  H. Remote
    1. Electrical
    2. Hydraulic
    3. Others

VII. Hydraulics
  A. Fundamentals of liquids under pressure
  B. Pumps
    1. Positive displacement
      a. Gear
      b. Vane
      c. Piston
    2. Constant pressure
  C. Cylinders
    1. Single acting
    2. Double acting
  D. Fluid transmission
  E. Valves
    1. Master control
    2. Selective control
  F. The tractor system
  G. Special applications

VIII. Lubrication, Lubricants, Fuels
  A. Need for lubrication
  B. Principles of lubrication
  C. Lubrication systems
    1. Internal
    2. External
    3. Filter
    4. Breathers
    5. Pumps and reservoir
  D. Lubricants
    1. Fluid oils
    2. Semisolids
    3. Solids
  E. Classification and identification of lubricants
    1. American Petroleum Institute
    2. Society of Automobile Engineers
    3. Viscosity
    4. Additives
  F. Fuels
    1. Diesel
    2. Gasoline
    3. Others
  G. Classification and identification of fuels

IX. Internal Combustion Engine
  A. The engine
    1. Interal v. external combustion
      a. Four-stroke
      b. Two-stroke
    2. Spark v. compression ignition
  B. Timing of the engine
  C. The fuel system
    1. Combustion and fuels
      a. How fuels burn
      b. Difference in gasoline and diesel combustion
    2. Carburetion and injection
      a. Fuel flow and metering
      b. The venturi principle

c. Volitizing the fuels
3. The air cleaner
4. Maintenance of the fuel system
D. The electrical system
1. Ignition system
a. Battery
b. Coil
c. Distributor
d. Spark plugs
e. Meters, switches, controls
2. Glow plugs and heating units
3. Lighting
4. Starting motor and generator
5. Regulators, relays, other accessories
E. Cooling and lubricating system
F. Engine performance
1. Type differences
2. Design features
3. Exhaust system effect

X. The Tractor
A. Types of tractors
B. Transmission system
1. Clutch
2. Gear box
3. Automatic and power amplifiers
4. Differential and final drive
C. Brakes
D. Wheels and tires
1. Traction factor
2. Compaction factor
E. Power takeoff and pulleys
F. Operator's comfort, convenience, safety
G. Operating the tractor

XI. Hitches and Power Measurement
A. Hitching for safety
B. Point of pull
C. Lines of force
D. Tractor tests and performance
E. Cost estimating

XII. Other Power Engines

Recommended Laboratory Projects (48 hours)

1. Introduction to laboratory facilities and and power units. Have students make safety chart and take safety test. (3 hours)
2. Have engine and power unit components and parts; let students identify them and explain function. Using cutaways, let student cross-check demonstrations. (3 hours)
3. Demonstrate simple machines and a power output test of an engine. Have students calculate results and do other problems. (3 hours)
4. Using cutaways or other visual aids, have student draw and label various methods of power transmission. (3 hours)
5. Run tests on principles of hydraulics and complete hydraulic systems with written reports accompanying test results. (6 hours)
6. Visit a supplier or have representatives come to class and give demonstration on lubrication and fuels. (3 hours)
7. The student will run various tests and study problem solving on the various aspects of the internal combustion engine: evaluating, trouble shooting, and reporting results using drawings and written and oral reports. (9 hours)
8. Run tests, make evaluation of performance of tractor components and the unit as a whole. Include dynamometer, traction, and compaction tests. (12 hours)
9. Demonstrate hitching, and hitching and pulling safely. Run pulling force tests on straight, side, and around corner pulls. (6 hours)

Texts and References

BARGER, *Tractors and Their Power Units*
BROWN *and* MORRISON, *Farm Tractor Maintenance*
HUNT, *Farm Power and Machinery Management*
JONES, *Farm Gas Engines and Tractors*
PIPE, *Small Gasoline Engines Training Manual*
PROMERSBERGER *and* BISHOP, *Modern Farm Power*
RAU, *Solar Energy*
RICHEY *and others*, *Agricultural Engineers' Handbook*
SHEPHERD, *Introduction to the Gas Turbine*
SHIPPEN *and* TURNER, *Basic Farm Machinery*, Vol I.
SOCIETY OF AUTOMOTIVE ENGINEERS, *Engineering Know-How in Engine Design*
TAYLOR, *The Internal Combustion Engine*

Farm Records and Reports

Hours Required

Class, 2; Laboratory, 0.

Course Description

A course to provide an understanding of how to keep and use the records of the farm business. Written reports on various farm operations are required as part of the course work.

This course is designed to give students an understanding of the principles and practices used in determining farm returns. By means of examples and problems, students will become acquainted with accounting principles. They will learn what records must be kept, how the information is to be recorded, and how such information is summarized for use.

Keeping of a set of records for a representative farm of the area should be included in the course. Such records should cover the period of a calendar year and include several enterprises.

There are many farm record books available. To these the instructor may add those forms that he feels necessary.

Writing various types of reports is included in this course. This is done to develop skills that can be used to explain and interpret information which is available only as a result of keeping accurate records.

Major Divisions

		Class hours
I.	Farm Records	2
II.	Methods of Measuring Farm Income	2
III.	Diary and Reports	2
IV.	Financial Statement	2
V.	Inventories	4
VI.	Farm Expenses	2
VII.	Farm Receipts	2
VIII.	Use of Journal	2
IX.	Budgets	2
X.	Written Reports	6
XI.	Production Records	2
XII.	Summarization and Future Use of Records	4
	Total	32

Units of Instruction

I. Farm Records
  A. Records organize information
    1. Making decisions
    2. Determine income
    3. Credit use
    4. Tax forms
  B. Necessity of records
    1. Planning
      a. Budgets
      b. Calendar of operations
      c. Crop program
    2. Financial
      a. Diary
      b. Inventory
      c. Financial statement
      d. Journal
    3. Analysis
      a. Cost of production
      b. Production
      c. Enterprise
      d. Farm
  C. Devising needed forms
    1. Time cards
    2. Equipment use
    3. Current inventories
  D. Tool of farm management

II. Methods of Measuring Farm Income
  A. Methods
    1. Net cash income
    2. Net farm income
    3. Operator's labor income
    4. Operator's labor earnings
    5. Percentage return of investments
  B. Terminology
    1. Assets
    2. Liabilities
    3. Income
    4. Expense
    5. Inventory
    6. Capital investment
    7. Interest
    8. Depreciation
    9. Prerequisite
    10. Equity
    11. Financial statement
  C. Practice exercises

III. Diary and Reports
  A. Record
    1. Labor
    2. Sales
    3. Expenses
    4. Farm activities
  B. Emphasis on:
    1. Neatness
    2. Accuracy
    3. Completeness
  C. Forms

    1. General
    2. Specific
  D. Written reports; farm happenings

IV. Financial Statement
  A. Assets and liabilities
    1. Anytime
    2. Ownership
    3. Net worth
    4. Use for credit
  B. Status
    1. Current
    2. Intermediate
    3. Long term
  C. Calculation of net worth

V. Inventories
  A. Record of ownership
    1. Capital investment
    2. Farm supplies
  B. Value
    1. Net selling price
    2. Cost less depreciation
    3. Cost or market price
    4. Replacement cost less depreciation
    5. Income capitalization
  C. Use
    1. Net farm income
    2. Net farm worth
  D. Depreciation
    1. Methods
      a. Straight line
      b. Declining balance
      c. Sum of digits
    2. Calculations

VI. Farm Expenses
  A. Kinds
    1. Capital
    2. Production
      a. Farm
      b. Enterprise
    3. Change in inventory
  B. Forms
    1. Columns needed
    2. Arrangement
  C. Making entries
    1. Accurate
    2. Complete
    3. Proper columns
  D. Writing checks
  E. Practice exercises

VII. Farm Receipts
  A. How recorded
    1. Capital
    2. Enterprise
    3. Miscellaneous
  B. Writing receipts
  C. Practice exercises

VIII. Use of Journal
  A. Setting up
    1. Relation
      a. Receipts
      b. Items
      c. Expenses
    2. Columns needed
      a. Entire farm
      b. Detailed accounts
      c. Provisions
  B. Making entries
  C. Transfer to enterprise
  D. Reconciling bank statements
  E. Practice exercises

IX. Budgets
  A. Planning record
  B. Concern
    1. Farm
    2. Enterprise
  C. Cash and noncash
  D. Comparison with actual
  E. Practice exercises

X. Written Reports
  A. Requirements
    1. Accurate
    2. Specific
    3. Organized
    4. Grammatically correct
  B. Types
    1. Descriptive
    2. Reports
    3. Legal
  C. Practice exercises

XI. Production Records
  A. Purpose of Production Records
    1. Figuring yield per unit
    2. Figuring cost per unit
    3. Figuring income per unit

    4. Providing quality data
  - B. Need special forms
  - C. Devise
    1. Maps
    2. Tree charts
    3. Barn sheets
  - D. Summarization
    1. Information
    2. Value

XII. Summarization and Future Use of Records
  - A. Information
    1. Current operation
    2. Future budgets
  - B. Efficiency of production
    1. Capital
    2. Labor
  - C. Value of records
  - D. Basis of comparison
    1. Enterprises
    2. Fields
    3. Years
    4. Operator
    5. Methods
  - E. Computers
    1. Value to farmer
    2. Information required
    3. Use of information obtained. (Have local farmer using computer service or operator of such service as speaker)

Texts and References

Hopkins *and* Heady, *Farm Records and Accounting*
Sheff, *Bookkeeping Made Easy*
U.S. Department of Agriculture, *Financial Calculations and Physical Measurements*

Irrigation and Water Management

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course in the principles and practices of irrigation, including soil, water, and plant relations; and water sources, quality, methods of distribution, and measurement. Irrigation application methods and structures, field preparation, and water measurement are included in the laboratory work.

Students will study the influence on irrigation practices of movement of water through soil, different crops, climate, land topography, and water supply. Emphasis is placed on means of improving irrigation efficiency for the conservation of water and the optimum production of quality crops. A survey is made of water requirements of various crops and the influence of climate and soil on these requirements. Various methods of water measurement and soil moisture determination are used.

A detailed study of each method of irrigation is made to determine its advantages and relationship to the crop and soil. Students will make field studies of land preparation and the structures used in water conveyance, development, and storage. Problems in crop culture which result from irrigation are considered.

Laboratory periods are used to test and evaluate the various irrigation equipment and instruments. Every effort is made to give actual practice in as many of the techniques and problems involved in irrigation for improved crop production.

Figure 23.—Irrigation is becoming more and more important to farm crop production. The application of fertilizers in irrigation water introduces further scientific and technological problems which the successful producer must understand.

Major Divisions

		Class hours
I.	Irrigation, Value and Use	2
II.	Soil, Water, Plant Relations	5
III.	Water Sources, Distribution, Measurement	7
IV.	Determining Water Use and Needs	2
V.	Application Methods and Structures	8
VI.	Legal and Administrative Aspects	4
VII.	Farm Ponds	2
VIII.	Water Efficiency	2
	Total	32

Units of Instruction

- I. Irrigation, Value, Use
  - A. Define irrigation
  - B. Importance of irrigation
  - C. Trends in water use
  - D. Relationship of precipitation to irrigation

- II. Soil, Water, Plant Relations
  - A. Soil
    - 1. Texture, structure, porosity
    - 2. Gravity
  - B. Soil moisture and its movement
    - 1. Types of soil moisture
    - 2. Movement of moisture through soil
  - C. Plant functions
    - 1. Availability of soil water
    - 2. Plant use and pickup methods
  - D. Measurement of soil moisture
    - 1. Soil sampling
    - 2. Instruments for soil moisture measurement
  - E. Effects of introducing irrigation
    - 1. Beneficial
      - a. Added variety of crops
      - b. Greater yields
      - c. Better control of harvest
      - d. More effective use of chemicals
    - 2. Possible adverse responses
      - a. New weed problems
      - b. New pest problems
      - c. New plant disease problems
      - d. Effects of chemistry of water on irrigation equipment

- III. Water Sources, Distribution, Measurement
  - A. Water sources
    - 1. Water cycle
    - 2. Ground water
    - 3. Methods of storage
      - a. Farm ponds
      - b. Conservation dams
      - c. Reservoirs
  - B. Pumping and transporting water
    - 1. Pumps and pumping
    - 2. Deep well pumping
    - 3. Canals and ditches
    - 4. Flumes and culverts
    - 5. Diversion devices
  - C. Water measurement
    - 1. Units of flow and measurement
    - 2. Waterhead and flow
    - 3. Contracted weirs
    - 4. Parshall flumes
    - 5. Other measuring devices
  - D. Water quality
    - 1. Soluble salts
    - 2. Insoluble salts
    - 3. Sediment
    - 4. Pollutants
      - a. Organic
      - b. Inorganic

- IV. Determining Water Use and Needs
  - A. Factors affecting water use
    - 1. Evaporation
    - 2. Transpiration
    - 3. Soil Porosity
    - 4. Organic content
    - 5. Nutrient Composition
    - 6. pH
  - B. Determining water needs
    - 1. Use of instruments
    - 2. Plants as indicators
    - 3. Cultural practices
    - 4. Crop grown
    - 5. Chemical relationships
    - 6. Application methods

- V. Application Methods and Structures
  - A. Surface
    - 1. Flooding
    - 2. Furrow
    - 3. Borders, checks, basins
  - B. Subsurface
    - 1. Controlled
    - 2. Uncontrolled
  - C. Overhead
    - 1. Portable and semiportable
      - a. Line sets
      - b. Solid sets
    - 2. Permanent (special use in pastures, orchards and other low tillage crops)
  - D. Land preparation and structures.
    - 1. Land leveling
    - 2. Construction equipment
    - 3. Maintenance equipment

- VI. Legal and Administrative Aspects
  - A. Irrigation water rights
    - 1. Surface
    - 2. Ground
  - B. Administering water

        1. Private
        2. Quasi-public enterprises
        3. Public enterprises

VII. Farm Ponds
- A. Use
    1. Water conservation
    2. Irrigation
    3. Lagoons for manure disposal
    4. Recreation
    5. Reuse of waste water
- B. Site selection
    1. Soil type
    2. Soil profile
    3. Topography
    4. Amount of runoff
- C. Size
- D. Construction requirements
    1. Legal and programs
    2. Safety
        - a. Water
        - b. Dam site and construction
    3. Capacity and placement
- E. Maintenance
    1. Seepage
    2. Silting
    3. Weed and algae control
- F. Financing
    1. Construction costs
    2. Government programs

VIII. Water Efficiency
- A. Storage
- B. Conveyance
- C. Comparative costs
- D. Preventing water losses
    1. Transpiration losses
        - a. Timing applications
        - b. Proper amount
        - c. Controlling hydrophytes
    2. Evaporation losses
        - a. Proper application
        - b. Surface coating ponds and reservoirs
    3. Seepage losses
        - a. Lining
        - b. Earth materials
        - c. Sedimentation
        - d. Concrete
        - e. Shotcrete
        - f. Asphalt

Suggested Laboratory Projects (48 hours)

1. Plan and make a tour of laboratory and facilities. Have a safety discussion and test. Look at and discuss class or group projects. (3 hours)
2. Take a field trip and evaluate the quality of soil for irrigation. (3 hours)
3. Test the water-soil relationship: water infiltration, holding capacities, and available moisture. Place tensiometer, soil blocks, etc. for reading throughout semester. (3 hours)
4. Make collections of water samples from irrigation sources and perform analysis of content for its value to crops for irrigation. (3 hours)
5. Test and calculate water use and departure from soil. Determine rate of movement and replacement time and quality. (6 hours)
6. Make a study of surface irrigation methods, evaluating time, flow, infiltration rate at various points in a run. Continue with a similar check study on subsurface and overhead. (9 hours)
7. Take a field trip to a sprinkler company to study design, use, and evaluation of systems. (3 hours)
8. Do a land preparation study. Learn the operation of a level, laying out a grid system for contouring, and processing of small dam construction. (6 hours)
9. Put a contour system in a plot of land. This can be done to enable application of water and/or for drainge. (3 hours)
10. Take a field trip to a well; test for pump and water management study. (3 hours)
11. Take a field trip to an irrigation district to understand water supply. (3 hours)
12. Take a field trip to a soil conservation district to evaluate drainage problems. (3 hours)

Texts and References

DRUGGER, *Getting Started in Irrigation Farming*
LAVERTON, *Irrigation, Its Profitable Use for Agricultural and Horticultural Crops*
OLIVIER, *Irrigation and Climate: New Aids to Engineering Planning and Development of Water Resources*
RUBEY, *Supplemental Irrigation for Eastern United States*
RUTTAN, *Economic Demand for Irrigated Acreage*
ZIMMERMAN, *Irrigation*

Mathematics and Science Courses

Mathematics I

Hours Required

Class, 3; Laboratory, 0.

Course Description

A course offering a basic mathematical program accenting the fundamental concepts of our number system, involving whole numbers, decimals, and fractions. These concepts are carried through elementary algebra to develop the principles of algebra and the use of algebraic formulas. Basic ideas on the use of the slide rule are introduced, especially for the solution of problems involving ratio, proportion, and percentage.

The objective of this course is to develop a greater understanding of our number system and its practical application to the problems involved in agriculture based upon his mathematical background in high school. An effort is made to transcend the meaning of numbers to a practical use which students can apply and understand. By developing mathematical concepts within the understanding of students, it is believed that sufficient motivation and interest can be created so that they can carry on these concepts through the use of directed numbers and the solving of problems in algebra. The course is more than a review of previous work and stresses the *use* of mathematics through pictorial and graphical representation and elementary statistics.

With the association of these mathematical concepts in practical problems, and the "busy" work eliminated with the use of the slide rule and Mathematical Tables Handbook, students will have more incentive to use and strengthen their understanding of the mathematical approach to problems.

The use of a Demonstration Slide Rule in class, the chalk board, participation of each student, and homework assignments all tend to correlate the development of the mathematical concepts of the student in agriculture.

Major Divisions

	Class hours
I. Review of Basic Mathematical Concepts	3
II. Introduction to Slide Rule	3
III. Percentage Problems: Sales and Costs	3
IV. Units of Measure	9
V. Applications in Use of Slide Rule	3
VI. Review of Algebra Fundamentals	3
VII. Linear Equations and Systems	9
VIII. Algebraic Fractions and Fractional Equations	6
IX. Elementary Statistics	3
X. Applications in Agriculture Involving Literal Equations and Graphing	6
Total	48

Units of Instruction

I. Review of Basic Mathematical Concepts
  A. Fundamental operations; integers
  B. Mixed numbers and fractions
  C. Decimal numbers

II. Introduction to Slide Rule
  A. Fundamental operations
    1. Multiplication
    2. Division
    3. Square roots
    4. Cube roots
    5. Ratios and proportions
  B. Meaning of various scales
    1. C, D, CI, DI, A, B, K scales
    2. Relationship of scales to each other

III. Percentage Problems: Sales and Costs
  A. Meaning and use of percentage
  B. Sales and costs
    1. Percentage based on sales price
    2. Percentage based on cost price
  C. Applications
    1. Fertilizer rates and costs
    2. Figuring seed mixtures
    3. Mixing and applying agricultural chemicals
    4. Shrinkage losses

IV. Units of Measure
  A. Lengths, areas, volumes
  B. Formulas for general plane figures and solids
  C. Simple machines and levers
  D. Ratio and proportion procedures
  E. Types of measuring instruments

        1. Rulers, scales, protractors
        2. Calipers and micrometers
        3. Planimeters and verniers
        4. Balances and metering devices
    F. Problems involving measurement
        1. Mixing concrete
        2. Measuring lumber
        3. Estimating hay quantities
        4. Measuring land areas
        5. Weighing solid materials
        6. Metering liquid materials
    G. Use of metric system in length, area, volume, weight

V. Applications in Use of Slide Rule
    A. Ratio and proportion problems
        1. Mixing concrete
        2. Measuring and cutting lumber
        3. Pearson square
        4. Figuring gear ratios
        5. Figuring pulley advantages
        6. Fulcrum and levers
        7. Use of C and D scales
    B. Square and cube roots
        1. Capacity of storage bins or tanks
        2. Estimating acreage
        3. Farm structures
        4. Use of A and B scales
    C. Reciprocals
        1. Decimal equivalents
        2. Percentage
        3. Use of CI and DI scales

VI. Review of Algebra Fundamentals
    A. Use of directed numbers
    B. Use of parenthesis, brackets, braces, vinculum
    C. Transposing unknown in formulas
    D. Problems involving formulas
        1. Centigrade to Fahrenheit
        2. Laws of physics
        3. Laws of chemistry
        4. Hydraulics

VII. Linear Equations and Systems
    A. Equations
        1. Operations involved in solving equations
        2. The degree of an equation
        3. Transposing an equation
    B. Systems of linear equations
        1. Equations involving two or more unknowns
        2. Solutions by addition and subtraction
        3. Solutions by substitution
        4. Solutions by multiplication and division
        5. Use of determinants
            a. Matrix method
            b. Basket weave
        6. Graphical solutions

VIII. Algebraic Fractions and Fractional Equations
    A. Algebraic fractions
        1. Review method of finding L. C. M.
        2. Operations involving fractions
            a. Multiplication by prime factors
            b. Division by prime factors
    B. Fractional equations
        1. Multiplication
        2. Division
        3. Addition
        4. Finding prime factors in equations

IX. Elementary Statistics
    A. Definition of terms
        1. Arithmetic and geometric progressions
        2. Mode
        3. Median
        4. Standard Deviation
        5. Harmonic mean
    B. Inequalities
    C. Summation techniques
    D. Analyzing grouped and ungrouped data
    E. Probability (binomial)
    F. Standard normal distribution
    G. Prediction from samples
    H. Correlation and regression
    I. Graphical representation
        1. Bar graphs
        2. Circle graphs
        3. Line graphs

X. Applications in Agriculture Involving Literal Equations and Graphing
    A. Solutions by mathematics
    B. Solutions by graphing
    C. Problems
        1. Farm operations
        2. Production
        3. Storage
            a. capacity
            b. heating and drying

Texts and References

Chase, *Elementary Statistics*
May, *Foundations of Modern Mathematics*
McGee, *Mathematics in Agriculture*
Rees, *Principles of Mathematics*
Rice *and* Knight, *Technical Mathematics and Calculus*
Slide Rule with C, D, CI, DI, S, T, ST, A, B, K, and log scales (Keuffel & Esser, Dietzgen, or Lietz)

Mathematics II

Hours Required

Class, 3; Lavoratory, 0.

Course Description

A course offering a program of algebra, basic logarithms, and numerical trigonometry. An introduction to the concepts in calculus is provided by the introduction to graphical methods. Areas, volumes, ratios, percentages, proportions, and simple and compound interest are covered using trigonometric and logarithmic methods, together with rates of change and ideas concerning maxima and minima.

The objective of this course is to build upon the fundamental knowledge which students have developed through simple algebra, and the use of the slide rule and mathematical tables. This course involves algebra of higher degree, the ideas of imaginary numbers and what they mean in this electronic age, and the graphing of problems to obtain solutions. The basic ideas of logarithms and numerical trigonometry are studied in order that the student can solve most problems arising in agricultural processes such as those involving areas, volumes, physics, chemistry, and financial obligations of interest, taxation, and mortgages.

The chalk board, demonstration slide rule, homework assignments, and individual participation of students are all considered essential to the full development of the concepts of this course.

Major Divisions

		Class hours
I.	Algebra of Higher Degree	9
II.	Introduction to Analytic Geometry	3
III.	Exponents and Radicals	3
IV.	Logarithms	6
V.	Numerical Trigonometry	6
VI.	Trigonometric Functions for Angles in All Four Quadrants	3
VII.	Solution of Oblique Triangles and Applied Problems	6
VIII.	Use of Slide Rule in Solving Problems Involving Logarithms and Trigonometry	6
IX.	Introduction to Concepts of Calculus	3
X.	Calculus by Graphical Representation	3
	Total	48

Units of Instruction

I. Algebra of Higher Degree
  A. Equations of higher degree
    1. Factoring (general and special cases)
    2. Completing the square to create a general case
    3. The solutions by use of the quadratic formula
  B. Simultaneous quadratic Equations
    1. Algebraic solutions of quadratic equations
    2. Algebraic solutions of equations in one linear and one quadratic
    3. Elimination of constants
    4. Reduction to simpler systems

II. Introduction to Analytic Geometry
  A. The meaning of a function in mathematics
  B. The rectangular coordinate system
  C. Graphs of general equations
    1. The parabola
    2. The hyperbola
    3. The ellipse
    4. The circle
  D. The point slope formula, ie: $y = mx + b$

III. Exponents and Radicals
  A. Review of the rules regarding exponents
  B. Numbers in the radical form and exponential form
  C. Meaning of complex numbers and the J operator
  D. Rate of growth and compound interest law
  E. Rationalizing the denominator

IV. Logarithms
  A. Meaning
  B. Numbers to bases other than 10
  C. Fundamental operations
    1. The characteristic and mantissa

2. Fundamental operations of multiplying, dividing, raising to a power, and finding the root of numbers by logarithms
3. Exponential equations
4. Antilogarithms

V. Numerical Trigonometry
   - A. The theorem of Pythagoras
   - B. The basic functions
      1. Sine
      2. Cosine
      3. Tangent
   - C. Trigonometric tables
   - D. Solutions of right triangles
   - E. The law of sines
   - F. The law of cosines

VI. Trigonometric Functions for Angles in All Four Quadrants
   - A. The sign of the function in each quadrant
   - B. The numerical value of an angle dependent upon the quadrant in which it lies
   - C. The reciprocal functions as distinguished from the cofunctions.
   - D. The graphing of trigonometric functions
   - E. Use of calculators and computers

VII. Solution of Oblique Triangles and Applied Problems
   - A. Solution when three sides given
   - B. Solution when two sides and an angle opposite one side are given
   - C. Solution when two sides and an included angle are given
   - D. Applications involving areas of land and volumes of storage facilities

VIII. Use of Slide Rule in Solving Problems Involving Logarithms and Trigonometry
   - A. Solutions of right triangle by slide rule
   - B. Solution of oblique triangle by slide rule
   - C. Solution by slide rule of problems involving angles less than 5 degrees
   - D. Logarithmic solution of right triangles
   - E. Logarithmic computations on a slide rule

IX. Introduction to Concepts of Calculus
   - A. The necessity of knowing the meaning of calculus
   - B. The delta method
   - C. Relationship of rate of change and first differentials to tangents in trigonometry
   - D. The meaning of maxia and minima
   - E. Differentiation and integration defined

X. Calculus by Graphical Representation
   - A. Approximate integration
      1. Trapezoidal Rule
      2. Simpson's Rule
   - B. Differentiation by graphing
      1. Plotting the slope and rate of change of the slope
      2. Determining maxima and minima by graphing
      3. Problem solving by graphing a function

Texts and References

LEITHOLD, *The Calculus*
MAY, *Foundations of Modern Mathematics*
MCGEE, *Mathematics in Agriculture*
REES, *Principles of Mathematics*
RICE *and* KNIGHT, *Technical Mathematics and Calculus*
Slide Rule with C, D, CI, DI, S, T, A, B, K, and log scales (Keuffel & Esser, Dietzgen, or Lietz)

Agricultural Chemistry

Hours Required

Class, 2; Laboratory, 6.

Course Description

A basic course in the composition of matter and physical and chemical changes: fundamental laws and principles. The properties of the common elements and their compounds with their application to agriculture are studied. Laboratory sessions are designed to give practical application of the theory expressed in lectures.

The teaching of chemistry should be supplemented by demonstrations, models, and related work in the laboratory.

Laboratory experiments include gas laws, diffusion, separation of liquids and solids, melting and boiling points of compounds, titration determinations, chemical changes, and pH determinations. Later on in the course are oxidation-reduction reactions, chemistry of water, solutions, colloids, precipitation, and chemical analysis. By performing experiments in the laboratory, students acquire a facility for handling laboratory equipment, laboratory procedure, and an introduction to precise measurements.

The instructor will relate the lecture and laboratory principles to practical application whenever possible. Students should be told where the various tests or measurements are used in industry. Liaison with the instructors of technical subjects, where chemical principles are reinforced, is desirable to stress the practical application of chemistry to agriculture.

Major Divisions

		Class hours
I.	Atomic Structure	2
II.	Periodic Table	2
III.	Molecules and Valence	2
IV.	Oxidation and Reduction	3
V.	Laws of Gases	3
VI.	Chemical Formulas and Equations	4
VII.	Acid-Base Relationships	4
VIII.	Water and the Liquid State	4
IX.	Solutions	2
X.	Colloids	2
XI.	Organic Compounds	4
	Total	32

Units of Instruction

I. Atomic Structure
   A. Matter
      1. Definition
      2. Mass, weight, density
      3. States of matter
         a. Solid
         b. Liquid
         c. Gas
   B. Energy
      1. Definition
      2. Forms of energy
         a. Potential
         b. Kinetic
      3. Law of conservation of matter and energy
   C. Atomic Theory
      1. The atom
         a. Nucleus
         b. Electrons
      2. Mass of the atom
      3. Atomic number of an atom
      4. Isotopes
      5. Atomic weights

II. Periodic Table
   A. Classification of elements
   B. Determination of atomic numbers
   C. Arrangement of modern periodic table
      1. Period
      2. Group of family
         a. First period
         b. Second period
         c. Third period
         d. Fourth period
         e. Fifth period
         f. Sixth period
         g. Seventh period
   D. Value of the periodic table

III. Molecules and Valence
   A. Vocabulary
   B. Valence
      1. Atoms combine to form molecules
      2. Different combining capacity
   C. Definition of valence
   D. Cause of valence
      1. Types of chemical loading
         a. Ionic
         b. Covalent
   E. Atomic structure and chemical loading
   F. Structure of crystalline solids
      1. Element with several valences
      2. Radicals
   G. Table of valences and radicals

IV. Oxidation and Reduction
   A. Oxidation defined
   B. Combustion
   C. Extinguishing fires
   D. Spontaneous combustion
   E. Products of oxidation
   F. Reduction defined
   G. Oxidation and reduction occur simultaneously
   H. Oxidation numbers
   I. Oxidizing and reducing agents

V. Laws of Gases
   A. Vocabulary
   B. Pressure changes affect gas volumes
      1. Temperature
      2. Pressure
      3. Standard temperature and pressure
      4. Boyle's Law
   C. Temperature changes affect gas volumes

  - 1. Kelvin Temperature Scale
  - 2. Charles' Law
- D. Gas law formulas
  - 1. Combined use of Boyle's and Charles' Laws
  - 2. The behavior of real gases

VI. Chemical Formulas and Equations
- A. Chemical composition
  - 1. Significance
  - 2. Molecular weight
    - a. Formula weight of a compound from its formula
    - b. Finding percentage composition of a compound
    - c. Determining empirical formula of a compound
- B. Chemical equations
  - 1. Definition
  - 2. Factors in equation writing
  - 3. Procedure in writing equations
  - 4. General types of chemical reactions
    - a. Composition reactions
    - b. Decomposition reactions (six classes)
    - c. Replacement reactions (four classes)
    - d. Double replacement reactions
  - 5. Many reactions are reversible
  - 6. Energy of reactions
    - a. Energy of activation
    - b. Activity series of the elements
- C. Weight relations in chemical reactions
  - 1. Gram-atomic weight of element
  - 2. Mole of a substance
  - 3. Solving weight problems
    - a. Proportion method
    - b. Arithmetic method
    - c. Mole method
- D. Molecular composition of gases
  - 1. Law of combining volumes of gases
  - 2. Gay-Lussac's Law
  - 3. Avogadro's Hypothesis
  - 4. Molar volume of a gas
  - 5. Molecular weight of gases

VII. Acid-Base Relationships
- A. Vocabulary
- B. Important acids
- C. Modern definition of an acid
- D. Definition of a base
- E. Characteristics of hydroxides
- F. Standard solutions
  - 1. pH of a solution
  - 2. Known molality solution
  - 3. Known molarity solution
  - 4. Standard of equivalent weights
  - 5. Standard solution of known normality
- G. Standard solutions and titration
  - 1. Method
  - 2. Indicators in solution
- H. Salts
  - 1. Definition
  - 2. Reactions which produce salts
  - 3. Naming of salts

VIII. Water and the Liquid State
- A. Physical properties
- B. Used as a standard
- C. Chemical behavior of water
- D. Composition of water by volume
  - 1. Analysis
  - 2. Synthesis
- E. Composition of water by weight
- F. Purification of water
- G. Law of multiple proportions

IX. Solutions
- A. Vocabulary
- B. Properties of solutions
- C. Types of solutions
- D. Solution equilibrium
- E. Effect of pressure on solubility
- F. Influence of temperature on solubility
- G. Solvents are selective
- H. Freezing and boiling points differ from those of their solvents
- I. Molecular weights of solutes
- J. Crystallization

X. Colloids
- A. Suspensoids
  - 1. Characteristics
  - 2. Suspensoid preparation
  - 3. Precipitation of suspensoids
- B. Emulsoids
  - 1. Characteristics
    - a. Common gels
    - b. Biocolloids

XI. Organic Compounds
- A. Fuels

    1. Measuring heat content of a fuel
    2. Solid fuels
        a. Wood
        b. Peat
        c. Lignite
        d. Coal, coke
    3. Liquid fuels
    4. Gaseous fuels
        a. Natural gas
        b. Coal gas
        c. Bottled gas
        d. Explosive range of a gas
B. Petroleum
    1. Native, origin
    2. Refining
    3. Determining a good motor fuel
    4. Cracking
    5. Other products
C. Hydrocarbon substitution products
    1. Halogen substitution products of methane
    2. Carbon tetrachloride
D. Alcohols
E. Ethers, aldehydes, ketones, organic acids, esters
    1. Products
    2. Ethers
    3. Formaldehyde
    4. Acetone
    5. Organic acids: acetic, oxalic, tartaric, citric, salicylic
    6. Esters: fruit flavors
F. Soap and soapless detergents
    1. Products
    2. Saponification
    3. Soapless detergents and wetting agents

Suggested Laboratory Projects (96 hours)

1. Practice elementary chemistry, laboratory techniques. (3 hours)
2. Experiment with solids and liquids. (6 hours)
3. Study Charles' Law of Gases. (6 hours)
4. Separate liquids and solids. (6 hours)
5. Find melting and boiling points of compounds. (6 hours)
6. Evaluate acids and bases. (6 hours)
7. Make titrations. (6 hours)
8. Perform pH determinations. (3 hours)
9. Determine chemical changes such as preparation of oxygen and hydrogen, reversible reactions, and neutralization. (6 hours)
10. Study the chemistry of water such as salt and mineral determination, hardness, pH, hydrolysis, hydration, and synthesis. (9 hours)
11. Apply oxidation-reduction reactions. (6 hours)
12. Make solutions and demonstrate solubility. (9 hours)
13. Study colloids such as preparation and coagulation, turbidity of water, osmosis, viscosity of oil. (6 hours)
14. Cause a precipitate to form from solutions; recover and measure the precipitate. (6 hours)
15. Practice chemical analysis. (6 hours)
16. Perform separating and distilling experiments. (6 hours)

Texts and References

CRAFTS, *The Chemistry and Mode of Action of Herbicides*
DULL *and* others, *Modern Chemistry*
FREY, *College Chemistry*
GREGG, *Principles of Chemistry*
HOLUM, *Elements of General and Biological Chemistry*
NECHAMKIN, *Laboratory Problems Manual of General Chemistry*
NITZ, *Introductory Chemistry*
PAULING, *College Chemistry*
QUAGLIANO, *Chemistry*
ROUTH, *Fundamentals of Inorganic, Organic and Biological Chemistry*
RUSSELL, *Study Guide for Sienko and Plane Chemistry*
SANDERSON, *Principles of Chemistry*
SIENKO *and* PLANE, *Chemistry: Principles and Properties*
WOOD *and* KENNAN, *General College Chemistry*

Visual Aids

American Society for Metals, Metals Park, Ohio 44073
Metal Crystals in Action, 16mm., sound, color, 30 minutes

Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091
A series of 160 motion pictures done in cooperation with the American Chemical Society, all 16mm., sound, color, varying lengths of running time. Included are: *Gases and Gas Laws, Acids and Bases, Titration, Equilibrium, pH and Buffering, Thermochemistry, Laboratory Techniques, Organic Chemistry, Periodic Table, Oxidation and Reduction, Electrolysis,* and *Qualitative Analysis*

Modern Talking Pictures, 160 East Grand Avenue, Chicago, Ill. 60611

Valence and Molecular Structure, Pauling Series, 3 films, 16mm., sound, color, 50 minutes

National Bureau of Standards, Office of Technical Information and Publications, Washington, D.C. 20234

Trapping of Free Radicals at Low Temperatures, 16mm., sound, color, 13½ minutes

Shell Oil Co., Film Library, 149-07 Northern Boulevard, Flushing, N.Y. 11354

Crude Oil Distillation, 16mm, sound, 13 minutes, color

University of Iowa, Iowa City, Iowa 52240

Atomic Models, Valence, and The Periodic Table, 16mm., sound, color, 44 minutes

Sterling Movies U.S.A., Inc., 43 West 61st Street, New York, N.Y. 10036

The Lead Matrix, 16mm, sound, color, 27 minutes

U.S. Atomic Energy Commission, Division of Public Information, Washington, D.C. 20545

"A" is for Atom, 16 mm, sound, color, 15 minutes

Ward's Natural Science Establishment, Inc., Post Office Box 1712, Rochester, N.Y. 14603

Periodic Table of the Elements (Wall chart)

E. H. Sargent & Co., 4647 West Foster Avenue, Chicago, Ill. 60630

Oxidation-Reduction Reactions Predictor (chart)

Metric System (chart)

E. H. Sargent & Co., 4647 West Foster Avenue, Chicago, Ill. 60630

Organic Structure (models)

Crop Botany

Hours Required

Class, 2; Laboratory, 3.

Course Description

A course designed to provide students with a working knowledge of the fundamental structures and processes of plants. Topics included are plant anatomy, physiology, morphology, reproduction, and genetics as they relate to crop production. In the laboratory students will conduct experiments to better understand basic plant structures and processes.

Students are expected to learn the botanical terminology and function of each plant organ and emphasis will be placed upon those physiological processes which are of direct economic significance to crops.

In the laboratory, students will learn to identify the various anatomical structures and will have the opportunity to explore the physiological processes of the plant. Plant materials utilized for study will illustrate, as nearly as possible, those aspects of anatomy and physiology which are fundamental to the growth and development of crop plants.

Major Divisions

		Class hours
I.	Utilization, Classification, Basic Design of Crop Plants	4
II.	Plant Structures	8
III.	Fundamental Plant Processes	16
IV.	Heredity in Crop Plants	2
V.	Plant Ecology	2
	Total	32

Units of Instruction

I. Utilization, Classification, Basic Design of Crop Plants
  A. Utilization of plants by man
    1. Food
      a. For man
      b. For livestock and game
    2. Fiber
      a. Lumber
      b. Fuel
      c. Tobacco
      d. Others
    3. Aesthetic value
    4. Recreation
    5. Temperature regulation
    6. Drugs and stimulants
    7. Others
  B. Plant Classification
    1. The taxonomic system
      a. History
      b. The pattern
        (1) Thallophytes
        (2) Bryophytes
        (3) Tracheophytes, vascular plants
          (aa) Gymnosperms
          (bb) Angiosperms
    2. Important crop families
      a. Monocotyledons
        (1) Gramineae
        (2) Liliaceae
      b. Dicotyledons
        (1) Rosaceae
        (2) Solanaceae
        (3) Malvaceae
        (4) Compositae
        (5) Leguminosae
    3. Other systems of classification
      a. Life cycle
      b. Growth habits: height, etc.

- c. Economic significance
- d. Utilization by man
- e. Environmental requirements

- C. Basic design of crop plants
  - 1. Cell structure
    - a. Cell theory
    - b. Nucleus and cytoplasm
    - c. Cell surface
    - d. Types of cells
  - 2. Tissues
    - a. Meristematic
    - b. Epidermal
    - c. Cortex
    - d. Vascular
    - e. Pith
  - 3. Organs
    - a. Roots
    - b. Stems
    - c. Leaves
    - d. Flower parts, fruit, seed

- II. Plant structures
  - A. Stems
    - 1. Functions
      - a. Support
      - b. Conduction
      - c. Storage
      - d. Photosynthesis
    - 2. Types of stems
      - a. Woody
      - b. Monocotyledons
      - c. Herbacedus dicotyledons
      - d. Modified stems
        - (1) Tubers
        - (2) Twining
        - (3) Rhizomes
        - (4) Stolons
        - (5) Bulbs and corms
    - 3. External anatomy
      - a. Buds, types and functions
        - (1) Flower
        - (2) Leaf
        - (3) Mixed
      - b. Nodes and internodes
      - c. Leaf scars
      - d. Lenticels
      - e. Thorns
    - 4. Internal anatomy
      - a. Meristematic tissue
      - b. Permanent tissues
        - (1) Xylem
        - (2) Phloem
        - (3) Epidermis
      - c. Annual rings
        - (1) Significance of health
        - (2) Abnormalities
        - (3) Rays
        - (4) Knots
  - B. Roots
    - 1. Functions
      - a. Adsorption
      - b. Conduction
      - c. Storage
      - d. Anchorage
      - e. Reproduction
    - 2. Root types and extensiveness of root system
      - a. Tap root
      - b. Fibrous
      - c. Adventitious
      - d. Primary, secondary, rootlets, root hairs
    - 3. Cellular structure of root hairs and root caps
  - C. Leaves
    - 1. Functions
      - a. Photosynthesis
      - b. Transpiration
      - c. Protection
      - d. Storage
      - e. Reproduction
    - 2. Types and persistence
      - a. Dicotyledons v. monocotyledons
      - b. Gymnosperms of coniferales order
      - c. Simple v. compound
      - d. Evergreen v. deciduous
    - 3. Modifications
    - 4. Anatomy
      - a. Epidermis and cuticle
      - b. Stoma and guard cells
        - (1) Palisade parenchyma
        - (2) Spongy parenchyma
      - c. Veins
      - d. Epidermal hairs
  - D. Flowers
    - 1. Function: reproduction
    - 2. Types
      - a. Monocotyledons, grass
      - b. Dicotyledons, legume and composite
      - c. Perfect and imperfect
      - d. Raceme and cyme
    - 3. Flower parts

- a. Petals
- b. Sepals
- c. Stamen
  - 1) Anther, pollen
  - (2) Filament
- d. Pistil
  - (1) Ovary, ova
  - (2) Style
  - (3) Stigma
- e. Receptacle

- E. Fruit
  - 1. Function
  - 2. Types and development
    - a. Simple
      - (1) Pod, legumes
      - (2) Follicle, milkweed
      - (3) Capsule, pigweed
      - (4) Silique, crucifers
      - (5) Achene, composite
      - (6) Caryopsis, grains
      - (7) Samara, elm
      - (8) Schizocarp, carrot
      - (9) Nut, walnut
      - (10) Drupe, peach
      - (11) Berry, tomato
      - (12) Pome, apple
    - b. Aggregate, strawberry
    - c. Multiple, fig
- F. Seeds
  - 1. Function, reproduction
  - 2. Dispersal methods and devices
    - a. Wings
    - b. Plumed seeds
    - c. Barbed
    - d. Sticky seed coat
    - e. Forceful dehiscence
    - f. Floating
    - g. Consumed and transported by animals
  - 3. Seed anatomy: dicotyledons, bean
    - a. Embryo
      - (1) Cotyledons
      - (2) Radicle, hypocotyl
      - (3) Epicotyl or plumule
    - b. Seed coat, testa
      - (1) Hilum
      - (2) Micropyle
    - c. Endosperm (in castor bean)
  - 4. Seed anatomy: monocotyledon, corn
    - a. Embryo
      - (1) Hypocotyl
      - (2) Plumule
      - (3) Coleoptile
      - (4) Coleorhiza
    - b. Endosperm
    - c. Seed coat

- III. Fundamental Plant Processes
  - A. Photosynthesis
    - 1. Importance and magnitude
    - 2. Mechanism of photosynthesis
      - a. Hill's reaction
      - b. Equation
    - 3. Efficiency of photosynthesis
      - a. Light
      - b. Water
    - 4. Factors influencing the rate
      - a. Internal factors
      - b. External factors
    - 5. Inputs: sources and function
      - a. Carbon dioxide
      - b. Water
      - c. Light
    - 6. Chloroplasts
    - 7. Enzymes, minerals and structural conditions
    - 8. Products
      - a. Oxygen
      - b. Sugar
    - 9. Measuring photosynthesis
  - B. Transpiration
    - 1. Definition and importance
    - 2. The process
      - a. Stomata, guard cell apparatus
      - b. Evaporation
      - c. Diffusion
      - d. Cohesion theory and "transpiration pull"
    - 3. External factors affecting rate of transpiration
      - a. Atmospheric vapor pressure
      - b. Solar radiation
      - c. Atmospheric temperature
      - d. Air movement
      - e. Available soil moisture
      - f. Soil temperature
    - 4. Internal factors affecting rate of transpiration
      - a. Quantity of stomata
      - b. Distribution of stomata
      - c. Position of stomata
      - d. Cuticle

      - e. Reduction of surface area
      - f. Epidermal hair
- C. Adsorption and root-soil-moisture relations
  - 1. Water – active adsorption
    - a. Diffusion pressure deficit relations
    - b. Physiological mechanism of active absorption
    - c. Zones of active absorption
      - (1) Root hairs (most important)
      - (2) Zone of elongation
      - (3) Zone of root suberization and lignification
    - d. Factors inhibiting absorption
      - (1) Flooded soil
      - (2) Excessive salts in soil solution
    - e. Guttation
  - 2. Water, passive absorption
    - a. Transpiration pull
    - b. Tension in xylem tissue
  - 3. Draught resistance
    - a. Leaf modification
    - b. Colloidal gels
    - c. Root modifications
  - 4. Effects of water deficits on plant processes
    - a. Reduction of growth
    - b. Reduction of photosynthesis
    - c. Sugar and amino acid accumulations
    - d. Assimilation product accumulation
    - e. Increased respiration
    - f. "Hardening"
  - 5. Mineral absorption
    - a. Diffusion process
    - b. Absorption against diffusion gradient and energy required
    - c. Selectivity and concentration
    - d. Active adsorption during periods of no water absorption
    - e. Factors affecting
      - (1) Oxygen content of microenvironment
      - (2) Enzyme-like carriers.
      - (3) Availability
      - (4) Zone of absorption
      - (5) Age of root or root hairs
      - (6) Respiration rate
- D. Conduction: water, solutes, and sugars
  - 1. Mechanism of water transport
    - a. Transpiration
    - b. Xylem-tracheids and vessels and cohesive forces
    - c. Pressure and turgor pressure
    - d. Osmosis
    - e. Tension theory vs suction
  - 2. Pathways of water from soil to xylem tissue
    - a. Through cellular membranes and living cells
    - b. Through cell walls and intercellular spaces
  - 3. Mechanism of mineral transport
    - a. Xylem tissue
    - b. Water flow to top of plant
    - c. Mobile minerals
      - (1) Nitrogen
      - (2) Phosphorus
      - (3) Sulfur
    - d. Minerals of less mobility
      - (1) Calcium
      - (2) Iron
  - 4. Phloem and sugar transport
    - a. Sieve-tubes, living cells
    - b. Companion cells
    - c. Mechanism of transport
      - (1) Active transport involving individual molecules
      - (2) Flow of entire solution
      - (3) Pressure flow hypothesis
- E. Turgor pressure
  - 1. Definition and operation
    - a. Differentially permeable membrane
    - b. Free movement of water
    - c. Guard cells and all cells
  - 2. Controlling factors for diffusion
    - a. Presence of solute particles in the water
    - b. Existence of a turgor pressure
    - c. Temperature
    - d. Presence of water attracting colloids
  - 3. Wilting and plasmolized cells
    - a. Lack of turgor pressure
    - b. Osmotic water loss to medium more concentrated than cell
    - c. Plasmolyzing solution
    - d. Application to wilting and irrigation of crop plants
- F. Growth and development
  - 1. Cell elongation
    - a. Frey-Wyssling theory of bipolar

addition of parallelized microfibrils
b. Factors affecting
(1) Nutrition of cytoplasm
(aa) Auxin concentration
(bb) Phosphate enzyme activity
(cc) Amino acid concentrations
(dd) Nitrogen
(ee) Unknown enzyme systems
(2) Respiration rate
(3) Stage of development
(4) Temperature
2. Cell multiplication
a. Meiosis, reduction division
b. Mitosis
(1) Precise doubling of chromosomes
(2) Separation to daughter nuclei
(3) Cytoplasmic division
3. Cell and tissue differentiation
a. Protoderm
(1) Epidermis and cuticle
(2) Protection
(3) Gas exchange
b. Ground meristem
(1) Pith
(2) Cortex
(3) Pith rays
c. Procambium
(1) Phloem
(aa) Sieve tube
(bb) Companion cells
(cc Fibers
(dd) Parenchyma
(2) Vascular cambium
(3) Xylem
(aa) Tracheids
(bb) Vessel members
(cc) Fibers
(dd) Parenchyma
4. Plant growth regulators
a. Plant regulators: promote or inhibit
b. Growth regulators
c. Flowering regulators
d. Phytohormones, produced by plant
e. Growth hormones
f. Flowering hormones
g. Auxins
h. Antiauxins
i. Agricultural application of growth regulators
(1) Rooting of woody cuttings
(2) Production of parthenocrapic fruit
(3) Production of larger fruit
(aa) Flower thinning
(bb) Fruit thinning
(4) Preventing sprouting of potatoes, onions, and nursery stock
(5) Prevention of preharvest fruit drop
(6) Delay or hastening of fruit maturity
(7) Induction of flowers (pineapple)
(8) Herbicides, especially 2, 4D
G. Reproduction
1. Pollination
a. Agents of pollination
b. Types of pollination
(1) Self
(2) Cross
c. Compatibility
d. Pollen germination
2. Fertilization
a. Growth of pollen tube into embryo sac.
b. Sperm cell enter egg
c. Sperm cell enter endosperm
d. Withering of stigma and style
3. Development of the seed
a. Growth and development of the zygote to form embryo
b. Development of primary endosperm cell to form endosperm
c. Development of the integument to form seed coat
d. Absorption of nucellar tissue
e. Development of ovary tissue to form fruit
4. Germination
a. Factors essential for proper germination
(1) Viable seed
(2) Dormancy overcome
(3) Proper environment
(aa) Proper temperature
(bb) Oxygen
(cc) Moisture
(dd) Light on some seeds

- b. The process of germination
  - (1) Imbibition of water
  - (2) Swelling and often seed coat rupture
  - (3) Enzyme activity
  - (4) Respiration increase
  - (5) Translocation of nutrients
  - (6) Cell elongation and multiplication
  - (7) Radicle emerges
- c. Dormant seeds
  - (1) Reasons for dormancy
  - (2) Kinds of dormancy
    - (aa) External: seed coat impervious to gasses or moisture
    - (bb) Internal: after ripening, seeds which do not germinate when subject to proper environment and lack external dormancy
  - (3) Methods of overcoming dormancy
    - (aa) Scarification
    - (bb) Treatment with acid or hot water
    - (cc) Light treatment
    - (dd) Stratification
    - (ee) Gas treatment
  - (4) Kinds of germination
    - (aa) Hypogeal
    - (bb) Epigeal

H. Plant Biosynthesis
- 1. Starch synthesis
  - a. Glucose-1-phosphate to amylose
  - b. Glucose-1-phosphate to amylopectin
  - c. Combination of amylose and amylopectic to form starch.
  - d. Enzymes necessary
  - e. Complex intermediate steps
  - f. Insolubility of starch
  - g. Starch accumulations in crop plants
- 2. Starch digestion
  - a. Hydrolylic process
  - b. Formation of maltose or glucose
  - c. Amylase enzymes and intermediate steps
- 3. Fat synthesis and digestion
  - a. Ratio of hydrogen to oxygen
  - b. Sugar to glycerol and fatty acid
  - c. Combining of glycerol and three fatty acids and elimination of 3 molecules of water
  - d. Importance of enzymes
  - e. Insolubility of fat
  - f. Digestion of fat to glycerol and fatty acids with aid of water and enzymes
  - g. Application to oil crops
- 4. Protein synthesis and digestion
  - a. Amino acids from sugar nitrogen and often sulfur
  - b. Conversion of amino acids and phosphorus to protein, with elimination of water
  - c. Complex intermediate steps
  - d. Importance of enzymes
  - e. Resulting products of digestion
    - (1) Amino acids
    - (2) Phosphorus
    - (3) Organic acids and ammonia
    - (4) Carbon dioxide and water
  - f. Amino acids resulting from digestion and resynthesis
  - g. Applications to high protein crops
- 5. Assimilation
  - a. Definition
  - b. Location and process of assimilating
    - (1) Pigments
    - (2) Gums, resins, mucilages
    - (3) Tannins
    - (4) Latex
    - (5) Alkaloids
    - (6) Antibiotics
    - (7) Poisons
    - (8) Phytohormones
    - (9) Vitamins
    - (10) Enzymes
  - c. Importance and agricultural applications

I. Respiration
- 1. Definition
- 2. Enzymes in the reaction
- 3. Mechanism of respiration
- 4. Factors affecting respiration
  - a. Temperature
  - b. Carbon dioxide concentration
  - c. Oxygen concentration
  - d. Light and nutrition
- 5. Applications to crop plants

J. Abscission
- 1. Definition and occurrence

- a. Leaf fall
- b. Flower and fruit drops
- 2. The mechanism
  - a. Cell division
  - b. Middle lamella breakdown
  - c. Cell dissolving
  - d. Cork formation
  - e. Vessel plugging by gums or tyloses
- 3. Agricultural importance
  - a. Cotton and defoliants
  - b. Apple and pear drop
  - c. Citrus drop

- IV. Heredity in crop plants
  - A. History and importance of plant genetics
  - B. Laws of inheritance
  - C. Review of meiosis
  - D. The monohybrid and dihybrid crosses
    - 1. Dominance and recessiveness
    - 2. Homozygous and heterozygous
  - E. Inbreeding and cross breeding
    - 1. Hybrid corn
    - 2. Hybrid alfalfa
  - F. Interactions of genes and modified ratios tios
  - G. Linkage and crossing over
  - H. Breeding to develop disease or insect resistant strains
  - I. Mutations
  - J. Laws of probability and application to crop breeding

- V. Plant Ecology
  - A. Importance of ecology
    - 1. Food supply
    - 2. Fiber, forest through cotton
    - 3. Individual plant, autecology
    - 4. Plant communities, synecology
  - B. The hydrosphere
    - 1. The water cycle
    - 2. Response of plants
      - a. Drouth
      - b. Excessive water
    - 3. Thermal properties of water
      - a. Cooling
      - b. Thermal energy storage
      - c. Heat Absorption
    - 4. Water quality
      - a. Salt content
      - b. Mineral content
        - (1) Boron
        - (2) Selenium
  - C. The lithosphere
    - 1. Minerals and plant responses
      - a. Toxic minerals
      - b. Deficiency responses
        - (1) Nitrogen
        - (2) Phosphorus
        - (3) Potassium
        - (4) Calcium
      - c. Selectivity and mineral accumulation by roots
    - 2. Soil
      - a. Anchorage potential and reponse
        - (1) Depth
        - (2) Particle size
        - (3) Tilth
      - b. Water holding ability
      - c. Air potential
      - d. Organic matter
      - e. Color and heat relations
  - D. The atmosphere
    - 1. Temperature
    - 2. Light intensity and day length
    - 3. Wind
    - 4. Contents
      - a. Pollutants
      - b. Moisture
      - c. Oxygen cycle
      - d. Carbon cycle
    - 3. Nitrogen cycle
  - E. The biosphere
    - 1. Plants
      - a. Symbiosis, disjunctive: plants not in contact with each other
        - (1) Nutritive: one derives food from others
          - (aa) Antagonistic
          - (bb) Reciprocal
        - (2) Social
          - (aa) Competition
          - (bb) Beneficial
      - b. Symbiosis, conjunctive
        - (1) Mutualistic: both plants benefit
        - (2) Commensalistic: one plant benfits, the other not harmed
        - (3) Parasitic: one benefits while other suffers

Suggested Laboratory Projects (48 hours)

1. Classify and identify crop plants. (3 hours)
2. Classify and identify stem anatomy, including buds. (3 hours)

3. Classify and identify root annatomy, microscopic work. (3 hours)
4. Classify and identify leaf anatomy microscopic work. (3 hours)
5. Classify and identify flowers and fruits. (3 hours)
6. Classify and identify pollen and seeds. (3 hours)
7. Determine influences of environment upon photosynthesis. (3 hours)
8. Measure and experiment with transpiration. (3 hours)
9. Experiment with nutrient uptake by roots. (3 hours)
10. Measure speed, quantity, and methods of conduction. (3 hours
11. Measure and experiment with tugor pressure. (3 hours)
12. Experiment with growth regulators on crop plants. (3 hours)
13. Determination of ideal environmental conditions for various crop seeds; also conduct experiments with seed dormancy. (3 hours)
14. Experiment with respiration and synthesis of complex molecules by plants. (3 hours)
15. Work genetic problems and make microscopic studies of abscission. (3 hours))
16. Take a field trip to observe factors in crop ecology. (3 hours)

Texts and References

GALSTON, *The Life of the Green Plant*
STEWARD, *Plants at Work*
WEISZ *and* FULLER, *The Science of Botany*

Visual Aids

Coronet Films, Coronet Building, Chicago, Ill. 60601
Plant Tropisms and other Movements, color, 16mm, 11 minutes

Encyclopedia Britannica Films, Encyclopedia Britannica Education Corp., 425 North Michigan Avenue, Chicago, Ill. 60611
Seed Dispersal (2nd edition)
Plant Motions—Roots, Stems, Leaves, color, 16mm, 11 minutes
Roots or Plants 2nd edition, black & white, 16mm, 11 minutes

The Growth of Plants, color, 16mm, 21 minutes
American I.B.S., McGraw-Hill Text Film Division, 330 West 42nd Street, New York, N.Y. 10018
Multicellular Plants, color, 16mm, approx. 28 minutes
A series of 10 films on plant parts and functions

General Courses

Agricultural Economics

Hours Required

Class,3; Laboratory, 0

Course Description

A course in the economic development of modern agriculture. The economic problems of agricultural production and marketing are covered. The changing role of modern agriculture and its social and political implications are emphasized.

The material in this course is designed to acquaint the students with the many "problems" which comprise the so-called "farm problems" in the United States. The course is more market oriented than production oriented. The problems of farm management are included in other courses.

The instructor must keep abreast of current statistics and articles on agricultural economics so that the information presented in class is as current as possible.

Major Divisions

		Class hours
I.	Introduction to Agricultural Economics	6
II.	Agricultural Production	6
III.	Agricultural Prices	6
IV.	Domestic Consumption and Marketing	6
V.	World Consumption and International Trade	3
VI.	Economic Resources in Agriculture	3
VII.	Agricultural Control	6
VIII.	Economics of Local Agriculture	3
IX.	Public Relations in Agriculture	6
X.	Future Trends in Agricultural Economics	3
	Total	48

Units of Instruction

I. Introduction to Agricultural Economics
  A. Definition of terms
    1. Agricultural economics
    2. Economic laws
    3. Applied v. pure science

- B. Size and scope of agriculture
    - 1. Farming phase
    - 2. Service and supply phase
    - 3. Marketing and distribution phase
- C. The agricultural revolution
    - 1. Relationship to industrial revolution
    - 2. Economic developments
    - 3. Our present economic system

II. Agricultural Production
- A. Nature of farm production
    - 1. Number of farms
    - 2. Definition of a farm
    - 3. Farm size and income
    - 4. Family vs corporate farms
- B. Supply and demand
    - 1. Law of supply and demand
    - 2. Elasticity
    - 3. Law of diminishing returns

III. Agricultural Prices
- A. Price determination
    - 1. Purpose of pricing
    - 2. Cost-price squeeze
- B. Attempts at price stabilization
    - 1. Effects of wars and depression
    - 2. Effects of government programs

IV. Domestic Consumption and Marketing
- A. Nature of agricultural marketing
    - 1. Problems
    - 2. Promotion programs
- B. Consumption of agricultural products
    - 1. Population growth
    - 2. Industrial uses
    - 3. Possible ways to increase

V. World Consumption and International Trade
- A. World consumption
    - 1. Population growth
    - 2. Need vs effective demand
    - 3. Interaction of domestic and world production
- B. Agricultural exports
    - 1. Size and scope
    - 2. Leading commodities
    - 3. Leading importing countries
- C. Common market developments
    - 1. Europe
    - 2. Central America
    - 3. Latin America

VI. Economic Resources in Agriculture
- A. Land
    - 1. Acreage in use
    - 2. Farm sizes
    - 3. Future trends
- B. Labor
    - 1. Part-time farming
    - 2. Age of farm population
    - 3. Effects of rural development
- C. Capital
    - 1. Reasons for increase
    - 2. Past, present, and future sources
    - 3. Uses of financing
- D. Technology
    - 1. Means of development
    - 2. Adoption by farmers
    - 3. New farm philosophy

VII. Agricultural Control
- A. Private companies or corporations
    - 1. Through integration
    - 2. Contract farming
- B. Government
    - 1. Production controls
    - 2. Acreage controls
    - 3. Water use
    - 4. Taxation policies
- C. Farm groups
    - 1. Bargaining associations
    - 2. Cooperatives
    - 3. Marketing orders
- D. Social and political implications
    - 1. Commercial v. part-time farms
    - 2. Relationship of government and farmers

VIII. Economics of Local Agriculture
- A. Size and scope in state
    - 1. Income
    - 2. Commodities
- B. Trends in production
    - 1. Increasing enterprises
    - 2. Decreasing enterprises
    - 3. Specialization
    - 4. New commodities

IX. Public Relations in Agriculture
- A. Public relations
    - 1. Definition
    - 2. Uses in agriculture
    - 3. What city people should know about farming

- B. Implementing a public relations program
  - 1. The individual farmer
  - 2. Farmer organizations
  - 3. Laws affecting agriculture: odors, dust, etc.
  - 4. Interdependence of farm and city
  - 5. Agriculture's image in Congress

X. Future Trends in Agricultural Economics

- A. Farming in the future
  - 1. Effects on major enterprises
  - 2. Problems in production
  - 3. Problems in marketing
- B. The new farm philosophy
  - 1. The agri-business concept
  - 2. Who will be farmers
  - 3. Who will control farming

Texts and References

HATHAWAY, *Problems of Progress in the Agricultural Economy*

ROY, *Contract Farming U.S.A.*

SCHULTZ, *Economic Crises in World Agriculture*

SNODGRASS *and* WALLACE, *Agriculture Economics and Growth*

VINCENT, *Economics and Management in Agriculture*

Communications Skills

Course Description

Class, 4; Laboratory, 3.

Course Description

A course in oral and written communication designed to promote greater competency in recording, talking, writing, and listening. The laboratory period provides practice in the various skills using teaching machines, programed learning, and other instructional aids. It also includes some practice by every student in speaking before the class; an exercise usually best adaptable to class sections not exeeeding 25 or 30 students.

This course may be adapted to large or small lecture sections. The laboratory should be open all day and evenings too, if school schedules permit. The laboratory should be staffed with a technical teaching assistant to help students operate the machines, and teachers should be available to give individual help. Students should be assigned to at least three hours of laboratory per week and should check in and out of the laboratory. Extra use of the laboratory by students should also be encouraged.

The laboratory materials are designed to allow students to progress at their own rate and provide for periodic testing. The types of teaching materials included are only a sample of those available and new ones are available daily. The teacher should keep abreast of new materials as they are produced and evaluate them for inclusion in the course.

Major Divisions

		Class hours
I.	Communication and the Technical Specialist	4
II.	Using Resource Materials	4
III.	Sentence Structure	10
IV.	Written Expression	20
V.	Talking and Listening	14
VI.	Improving Reading Efficiency	12
	Total	64

Units of Instruction

I. Communication and the Technical Specialist

- A. Why the technical specialist must be proficient in the art of communication
- B. Why written communication is an essential skill
  - 1. Statements and facts
  - 2. Expression of ideas
  - 3. Technical reporting
    - a. Formal
    - b. Informal
  - 4. Use of graphics to illustrate written communications
- C. Why oral communication is an essential skill
  - 1. Person-to-person expression of ideas and thoughts
  - 2. Verbal reporting
- D. Diagnostic tests

II. Using Resource Materials

- A. Orientation in the use of the library
  - 1. Major systems of classification
    - a. Dewey decimal system (most common system)
    - b. Library of Congress system
  - 2. Use of individual learning aids and equipment
- B. Aids in using the library
  - 1. Call numbers

    2. Card catalogue
    3. Vertical file
    4. Open stack libraries
    5. Closed stack libraries
    6. Parts of a book
C. Examples of reference books
    1. General reference sources
        a. Besterman, *World Bibliographies of Bibliographies*
        b. Bibliographic Index: *A Cumulative Bibliography of Bibliographies*
    2. Catalogues
        a. *The Booklist*
        b. *Publisher's Trade List Annual*
        c. *The Reader's Adviser and Bookman's Manual*
        d. *The United States Catalog*
        e. *The Cumulative Book Index*
    3. Indexes to magazines, newspapers, and essays
        a. *Annual Magazine Subject Index*
        b. *American Newspapers*, 1821–1949
        c. *Directory of Newspapers and Periodicals*
        d. *International Index to Periodical Literature*, 1907 to date
        e. *New York Times Index*
        f. *Readers' Guide to Periodical Literature*, 1900 to date
    4. Encyclopedias
        a. *Chamber's Encyclopedia*
        b. *Encyclopedia Americana*
        c. *Encyclopedia Britannica*
        d. *New International Encyclopedia*
    5. Biographies
        a. *Biography Index*
        b. *Current Biography*
        c. *Dictionary of American Biography*
        d. *Dictionary of Canadian Biography*
        e. *Dictionary of National Biography* (British)
        f. *Who's Who*
        g. *Who Was Who*
    6. Dictionaries (unabridged)
        a. *A Dictionary of American English on Historical Principles*
        b. *New Century Dictionary*
        c. *New English Dictionary on Historical Principles*
        d. *New Standard Dictionary of the English Language* (Funk and Wagnalls)
        e. *Webster's New International Dictionary of the English Language*
    7. Yearbooks
        a. *The American Yearbook*
        b. *Annual Register*
        c. *Information Please Almanac*
        d. *National Catholic Almanac*
        e. *Statesman's Year Book*
        f. *Whitaker's Almanac*
    8. Atlases and gazetteers
        a. *Columbia Atlas*
        b. *Columbia-Lippencott Gazetteer of the World*
        c. *Encyclopedia Britannica World Atlas*
        d. *Hammond's Ambassador World Atlas*
        e. *Rand McNally Commercial Atlas and Marketing Guide*
    9. Guides to pamphlets and bulletins
        a. *United States Government Publications*
        b. *Subject Guide to United States Government Publications*
        c. *A Popular Guide to Government Publications*
        d. *United States Government Publications: Monthly Catalog*
        e. *Catalog of the Public Documents of Congress and of All Departments of the Government of the United States for the period 1893–1940.*
    10. Books of quotations
        a. Bartlett, *Familiar Quotations*
        b. Benham, *Benham's Book of Quotations, Proverbs and Household Words*
        c. Hoyt, *New Cyclopedia of Practical Quotations*
        d. Mencken, *A New Dictionary of Quotations on Historical Principles*
    11. Agriculture
        a. *Agriculture Index*
        b. Bailey,*Cyclopedia of American Agriculture*
        c. Bailey, *Standard Cyclopedia of Horticulture*
        d. *Dictionary of Terms Relating to*

        Agriculture, Horticulture, Forestry, etc.
    e. Bradley, *Index to Publications of the United States Department of Agriculture,* 1901–1930
    f. *Yearbook of Agriculture*

III. Sentence Structure: What is a sentence?
  A. Function words
    1. Noun indicators (determiners)
    2. Auxiliaries
    3. Intensifiers
    4. Prepositions
    5. Coordinating conjunctions (coordinators)
    6. Subordinating conjunctions (subordinators)
      a. Adverbial clause markers (subordinators)
      b. Noun and adjectival clause markers (relative pronouns)
      c. Transitional connectors (transitional conjunctions)
  B. Review of parts of speech
  C. Sentence patterns
    1. Subject-transitive verb-direct object
    2. Subject-transitive verb-indirect object-direct object
    3. Subject-linking verb-predicate adjective
    4. Subject-linking verb-predicate noun or pronoun
    5. Subject-intransitive verb
    6. Subject-passive voice verb
  D. Finding the subject and verb
    1. Intervening modifying elements
    2. Inversions
    3. Word groups as subject or verb
    4. Verb and verbals
    5. Command and request sentences
  E. Phrases
    1. Verbal
      a. Infinitive
      b. Participle
      c. Gerund
    2. Preposition
      a. P-group in the noun cluster and verb cluster
      b. Uses of the P-group: noun, adjective, adverb
  F. Clauses
    1. Independent or main clause
    2. Dependent or subordinating (S-group)
      a. S-group as part of noun cluster
      b. S-group as part of verb cluster
  G. Kinds of sentences
    1. According to function
      a. Statement (declarative)
      b. Question (interrogative)
      c. Imperative
      d. Exclamatory
    2. According to construction with clauses
      a. Simple
      b. Compound
      c. Complex
      d. Compound-complex
  H. Effective sentences
    1. Unity
    2. Variety
    3. Emphasis
    4. Coherence
    5. Coordination and subordination
    6. Loose and periodic sentences
    7. Balanced sentences
    8. Conciseness
    9. Sentence length
    10. Diction
  I. Sentence errors
    1. Fragment
    2. Comma splice and runtogether
    3. Mixed and illogical constructions
    4. Faulty coordination
    5. Faulty subordination
    6. Choppy sentences
    7. Passive voice sentences
    8. Dangling modifiers
    9. Misplaced modifiers
    10. Agreement, reference, case
    11. Confusion of adjectives and adverbs
    12. Trouble with verbs

IV. Written Expression
  A. What is a good paragraph?
  B. Characteristics of a good paragraph
    1. Unity
    2. Completeness
    3. Coherence
    4. Emphasis
  C. Unity
    1. Main idea or topic sentence
    2. Positions of main idea

- 3. Inferred main idea
- D. Completeness
  - 1. When is a paragraph complete?
  - 2. Length in word or sentence count
  - 3. Length determined by writer fulfilling his purpose
- E. Coherence
  - 1. What is coherence?
  - 2. Methods of achieving coherence
    - a. Consistent point of view
    - b. Using conjunctions and other connectives
    - c. Pronoun reference
    - d. Repetition of key ideas
    - e. Parallel structure
    - f. Transitional sentences and paragraphs
- F. Emphasis
  - 1. Methods of achieving emphasis
    - a. By grammatical rank
    - b. By the end and beginning positions
    - c. By inversions
    - d. By moving words out of their normal positions in a sentence
    - e. By using figures of speech
    - f. By an occasional short sentence
    - g. By arranging items in a series in order of climax
    - h. By using words in special ways
    - i. By the periodic sentence
    - j. By repetition of key ideas
    - k. By parallel structure
- G. Simple orders of development
  - 1. General to particular or deductive order
    - a. Repetition of topic sentence at end
    - b. Sentences arranged in question to answer pattern
  - 2. Particular to general or inductive order
    - a. Sentences arranged in order of climax
- H. Complex orders of development
  - 1. Comparison, contrast, analogy
  - 2. Analysis
    - a. By classification
    - b. By partition
    - c. By process
    - d. By cause and effect
  - 3. Definition
  - 4. Narration
  - 5. Description
  - 6. Combination of methods
- I. Structuring the outline
  - 1. Sentence outline
  - 2. Topic outline
  - 3. Paragraph outline
- J. Written exercises in the paragraph
- K. Letter writing
  - 1. Business letters
  - 2. Personal letters
- L. Mechanics
  - 1. Capitalization
  - 2. Punctuation
    - a. End punctuation: period, question mark, exclamation point
    - b. Comma
    - c. Semicolon
    - d. Colon
    - e. Dash
    - f. Parenthesis
    - g. Brackets
    - h. Apostrophe
- M. Spelling
  - 1. Thomas Clark Pollock's Spelling Report: *List of words*
  - 2. Rules
    - a. Dropping the final e
    - b. Doubling final consonant
    - c. ei or ie
    - d. Changing y to i
  - 3. Other aids to analysis of spelling problems
    - a. Distinguishing prefixes and suffixes from roots
    - b. Words with seed sound
    - c. Confusing forms, such as procedure, proceed, proceeded
    - d. Addition of unnecessary letters
    - e. Omission of necessary letters
    - f. Changing letters around
    - g. Confused endings
    - h. Single and double consonants
    - i. Words that sound somewhat alike but spelled differently
  - 4. Syllabification
  - 5. Visual memorization
- N. Problems in usage
  - 1. Adjectives and adverbs
  - 2. Case of pronouns
  - 3. Agreement of subject and verb
  - 4. Difficulties with verbs

- 5. Reference of pronouns
- 6. Effective sentences
  - a. Subordination
  - b. Coordination
  - c. Parallelism
  - d. Dangling modifiers
  - e. Misplaced modifiers
  - f. Shifts in construction
  - g. Comparisons
  - h. Comma splice
  - i. Runtogether sentences

V. Talking and Listening
- A. Characteristics of good speech
  - 1. Worthwhile subject
  - 2. Noteworthy purpose
  - 3. Good resource materials
  - 4. Captures listener's attention and interest
  - 5. Effective language and style
  - 6. Effective voice and diction
  - 7. Effective bodily actions
- B. How to select a subject
  - 1. Sources
  - 2. Purpose
  - 3. Limiting the subject
- C. Four basic objectives
  - 1. Inquiry
  - 2. Reporting
  - 3. Advocacy
  - 4. Evocation
- D. Gaining the confidence of the audience
  - 1. Confidence
  - 2. Tolerance and fair play
  - 3. Friendliness
  - 4. Sincerity
  - 5. Sense of humor
  - 6. Dignity
- E. Kinds of speeches
  - 1. Reading from a manuscript
  - 2. Speaking from memory
  - 3. Impromptu
  - 4. Extemporaneous
- F. Outlining the speech
  - 1. Kinds of outlines
- G. The divisions of speech
  - 1. Introduction
  - 2. Discussion or body
    - a. Central idea
    - b. Major support
    - c. Minor support
  - 3. Transitions
  - 4. Conclusion
- H. Effective use of language
- I. Developing an adequate speaking voice
- J. Developing effective body actions
  - 1. Movement of the whole body
  - 2. Gestures
  - 3. Posture
  - 4. Facial expressions
- K. Characteristics of good bodily action
  - 1. Coordination
  - 2. Vitality
  - 3. Integration
  - 4. Timing
  - 5. Variety
  - 6. Reserve
  - 7. Appropriateness
- L. Problems that plague the public speaker
  - 1. Getting to the platform
  - 2. Where to stand
  - 3. Moving around
  - 4. What to do with the hands
  - 5. Use of the speaker's stand
- M. Listening
  - 1. Reasons for listening
    - a. For facts
    - b. To analyze facts and ideas
    - c. To evaluate facts and ideas
    - d. For elaboration
    - e. For entertainment
    - f. To improve speaking
  - 2. Principles: listening is best
    - a. When listeners have a stake in what the speaker is saying
    - b. When speaker has a stake in what he is saying
    - c. When listener's motivation is real rather than artificial
  - 3. Basic needs that affect listening
    - a. Self-preservation
    - b. Property
    - c. Social approval
    - d. Integrity
    - e. Affection
    - f. Sentiment
    - g. Taste
    - h. Pleasure
  - 4. How to listen
    - a. Concentrate
    - b. Understand what to listen for
    - c. Critically

        - d. Use mechanical aids for listening
    - 5. Note-taking as an aid to listening

VI. Improving Reading efficiency
- A. Diagnostic tests
- B. Learning about reading
    - 1. Speed in reading
    - 2. Purpose and difficulty
    - 3. Flexibility
    - 4. Characteristics of a good reader
    - 5. Getting rid of bad habits
- C. Building a vocabulary
    - 1. Types of vocabulary
    - 2. Ways of building a vocabulary
        - a. Context clues
        - b. Direct explanation
        - c. Indirect explanation
        - d. Simile
        - e. Prefixes, suffixes, roots
    - 3. Vocabulary cards
- D. Reading the paragraph
    - 1. Locating the main idea
    - 2. Ferreting out facts
    - 3. Drawing inferences
    - 4. Sensing tone
    - 5. Noting the structural organization
    - 6. Skimming and scanning for specifics
    - 7. Following pronoun references
    - 8. Making conclusions
    - 9. Following the guide words
- E. Skimming
    - 1. Purpose of skimming
    - 2. Skimming the whole
    - 3. Skimming an article
    - 4. Previewing a book
- F. Scanning
    - 1. Difference between skimming and scanning
    - 2. Skill of scanning
- G. Intensive reading: study type reading
    - 1. Using the "SQ3R" method
        - a. Survey
        - b. Question
        - c. Read
        - d. Review
        - e. Recall
    - 2. Outlining what is read

Suggested Laboratory Projects (48 hours)

1. Practice skills of information discovery and collection (8 hours)

This laboratory is organized around prepared projects to give the student an opportunity to practice the skills of locating, evaluating, and collecting useful information. In addition, it provides colored slides for illustrative purposes and machine programs on library orientation. It includes also a guided tour of the library for orientation and work in the library on assigned topics.

- A. Using resource materials
    - (1) Orientation in the use of the library
        - a. A planned tour of the library
            - 1. Orientation in the use of the library
            - 2. Instructions in where library materials are placed
        - b. Teaching machine
            - 1. Library orientation program (films, slides, and other prepared materials)
    - (2) Aids to using the library
        - a. Teaching machines
        - b. Prepared materials
        - c. Independent projects
    - (3) Reference books
        - a. Independent projects
        - b. Prepared materials
    - (4) Tests and exercises

2. Practice Skills Involving Sentence Structure (10 hours)

This laboratory is organized around materials with which the student may do independent study. It may be necessary, therefore, for the teacher to create his own program for the teaching machines, although there are some programs available at the present time and there will be many more programs in the future. The laboratory program which follows stresses four kinds of materials: teaching machines including films); autoinstructional programed books already on the market, such as *English 2600*, *English 3200*, and *Correct Writing;* various traditional workbooks like *From Sentence to Paragraph* by Albert E. Di Pippo and *A Workbook for Writers* by Sachs *and others;* and exercises and tests already published or new materials prepared especially for the laboratory by the department or individual teacher.

- A. Sentence Structure
  - (1) Function words
    - a. Teaching machine
    - b. Lists prepared by teachers or in reference books, such as *Understanding English* by Paul Roberts and *Form in Modern English*
    - c. Exercises and tests
  - (2) Review of parts of speech
    - a. By teaching machine
    - b. By autoinstructional texts, such as: *English 3200*
    - c. By use of a *Workbook for Writers*
    - d. Exercises and tests
  - (3) Sentence patterns
    - a. Use teaching machines
    - b. Use autoinstructional texts, such as: *Correct Writing*
    - c. Use *A Workbook for Writers*
    - d. Exercises and tests
  - (4) Finding the subject and verb
    - a. Use teaching machines
    - b. Use autoinstructional texts, such as: *Correct Writing*
    - c. *A Workbook for Writers*
    - d. Exercises and tests
  - (5) Phrases
    - a. Use teaching machines
    - b. Use autoinstructional texts, such as: *Correct Writing*
    - c. *A Workbook for Writers*
    - d. Exercises and tests
  - (6) Clauses
    - a. Use teaching machines
    - b. Use autoinstructional texts, such as: *Correct Writing*
      English 3200
    - c. Use *A Workbook for Writers*
    - d. Exercises and tests
  - (7) Kinds of sentences
    - a. Use teaching machines
    - b. Exercises and tests
  - (8) Effective sentences: rhetorical patterns
    - a. Use teaching machines
    - b. Use autoinstructional texts, such as: *Effective Writing*
      Correct Writing
      English 3200
    - c. Paragraph materials prepared for the laboratory using overhead projector
  - (9) Show sentence errors
    - a. By teaching machines
    - b. By autoinstructional texts, such as: *Correct Writing*
      English 3200
    - c. Use *A Workbook for Writers*
    - d. By prepared sentence and paragraph materials for overhead projects

3. Practice skills involving written expression (10 hours)

The laboratory is designed primarily to aid the student in improving his mechanics and usage including capitalization, punctuation, and spelling. At the present time there are some programs in these areas already designed for teaching machines. Since most of the materials in parts one through 11 will be covered in class lectures and written assignments, the laboratory materials may be used independently by the student to help him correct errors in his written work. He may work also with films, texts, and SRA Compositon material.

- A. Written Expression
  - (1) Use programed materials, such as:
    - a. Ferster, *Programed College Composition*
    - b. Shurter *and* Reid, *A program for Effective Writing*
    - c. Bergman, *Paragraph Rhetoric: A Program in Composition*
  - (2) Use of films
  - (3) Use of SRA contemporary composition by Peterson
  - (4) Mechanics
    - a. Teaching machines
      - 1a. Practice punctuation program
      - 2b. Use independently prepared programs
    - b. Use programed texts, such as:
      Palmer, *The English Sentence: A Programed Course*
      Hook *and* Stevens, *Competence*

in English: A *Programed Handbook*
Ferster, *Programed College Composition*
Everett, Dumas *and* Wall, *Correct Writing*
Blumenthal *English 2600*

c. Use workbooks, such as:
Sachs *and* others, *A Workbook for Writers*
Hodges *and* Laws, *Harbrace College Workbook*

d. Tests and exercises

(5) Spelling
- a. Use programs prepared for teaching machines
- b. Use programed texts, such as:
  Hook, *Spelling 1500: A Program*
  Smith, *Spelling by Principles*
- c. Use spelling programs in other autoinstructional texts, such as:
  Everett, Dumas *and* Wall, *Correct Writing*
- d. Spelling tests
- e. Exercises in mechanics and usage

(6) Usage
- a. Use programs prepared for teaching machines
- b. Assign exercises in programed texts, such as:
  Hook *and* Stevens, *Competence in English*
  Blumenthal, *English 2600*
  Blumenthal, *English 3200*
  Sullivan, *Programed Grammar*
  Everett, Dumas *and* Wall, *Correct Writing*
- c. Exercises and tests

4. Practice skills involved in talking and listening (10 hours) This part of the study program must include actual practice in speaking before the class. This laboratory exercise is designed to give the student an opportunity to hear speeches by famous persons, such as Churchill, Roosevelt, Kennedy, and others. In addition, the student may tape his own speeches given before the class as an audience, and play them back for study purposes. The laboratory should include also among its reference materials many printed copies of famous speeches. It should include also films on speaking and listening. Some recommended films are the following:
University of Illinois, *Using your Voice*
University of Indiana, *Movements and Gestures*
University of Indiana, *Talking Ourselves into Trouble*
   A. Talking and Listening
      (1) Study tapes of famous speeches
      (2) Tape speeches of your own composition
      (3) Tests and exercises on organization, outlining, listening

5. Practice in improving reading efficiency (10 hours)
The reading laboratory is designed to give the student an opportunity to practice the skills and techniques of efficient reading with materials especially designed for reading improvement. The laboratory includes reading machines, programed texts, and standard reading materials. Individual programs should be set up for the students. The laboratory materials below, therefore, are some of the materials in the field; the instructor will use them as they fit the individual student needs.
   A. Improving Reading Efficiency
      (1) Diagnostic tests
      (2) Books for study and practice
         a. Canavan *and* King, *Developing Reading Skills*
         b. Canavan *and* Heckman, *The Way to Reading Improvement*
         c. Brown, *Efficient Reading*
         d. Carter *and* others, *Effective Reading for College Students*
         e. Judson, *The Techniques of Reading*
         f. Leedy, *Read with Speed and Precision*
         g. Leedy, *Reading Improvement for Adults*
         h. Sherbourne, *Toward Reading Comprehension*

      Note: Many of these books are self-teaching since they have the answers to all the exercises and test in the appendix. These are but a few of the many excellent reading books in the field and may be used for independent study and improvement.

(3) Vocabulary building
   a. Use programs prepared for teaching machines
   b. Assign materials in standard texts
   c. Use programed texts for vocabulary development, such as: Brown, *Programed Vocabulary* Everett, Dumas *and* Wall, *Correct Writing*

(4) Make use of individual programs in reading improvement with materials, such as:
   a. Science Research Associates, Inc., 259 East Erie St., Chicago, Ill. 60611
      Reading for Understanding by Thelma Gwinn Thurstone
      Pilot Library™ Series
      Reading Laboratory Series, developed by Don H. Parker
      Reading Laboratories IVa
      Power Builders™
      Advanced Reading Skills Program, developed by Elizabeth A. Simpson
      Words, developed by Susan Meyer Markle
   b. Craig Research, Inc., 3410 South La Cienega Blvd., Los Angeles, Calif. 90016
      Advanced Reading Program A
      Reading Program B

   Note: These programs are designed to accompany the Craig Reader: a machine for use by an individual, not a class.

   c. Educational Developmental Laboratories, 75 Prospect St., Huntington, N.Y. 11743
      Coast Visual Education Co., 6560 Hollywood Blvd., Hollywood, Calif. 90028
      1. KL series for controlled reader
         a. Exercises for KL series
      2. $\mathrm{H_sC}$ series
         a. Exercises for series
      3. IJ series
         a. Exercises for series
      4. Manuals and tests for series

   The controlled reader may be used with a class or by the individual student; it is designed for self-learning with a number of complete programs.

   Note: There are, of course, other programs in the field, the purpose in this outline is to suggest the possibilities available for independent reading improvement. The department, for example, might wish to consider "Learning 100" — a multimedia communication skills system — prepared under the direction of George D. Spache, Head of Reading Laboratory and Clinic at the University of Florida for Educational Developmental Laboratories, Huntington, N.Y. — A Division of McGraw-Hill. See also their "Reading 300 Lab". Auto-tutor by Welch Company has a vocabulary program.

Textbooks, References, and Visual Aids

To assist those who use this outline, the references for each of the five suggested laboratory projects (or Sections) have been listed separately as follows:

1. Using Resource Materials:

BARTON, *Reference Books: A Brief Guide for Students and Other Users of the Library*
HIRSHBERG, *Subject Guide to Reference Books*
HUTCHINS, *Introduction to Reference Work*
SHORES, *Basic Reference Sources*
WILSON *and* others, *Harbrace Guide to Dictionaries*
WINCHELL, *Guide to Reference Books*

2. Sentence Structure: Background and Resource Materials, General References

ALBAUGH, *English: A Dictionary of Grammar and Structure*
ROBERTS, *Patterns of English*
ROBERTS, *Understanding English*
TAFT, MCDERMOTT, JENSEN, *and* KAPLAN, *The Technique of Composition*

Programed Materials:
BLUMENTHAL, *English 2600*
BLUMENTHAL, *English 3200*

Everett *and* others, *An Auto-Instructional Text in Correct Writing*
Ferster, *Programed College Composition*
Hook *and* Stevens, *Competence in English: A Programed Handbook*
Palmer, *The English Sentence: A Programed Course*
Shurter *and* Reid, *A Program for Effective Writing*
Sullivan, *Programed Grammar*

Workbooks:
Di Pippo, *From Sentence to Paragraph*
Hodges *and* Laws, *Harbrace College Workbook*
Sachs *and* others, *A Workbook for Writers*
Willis, *Structural Grammar and Composition*

Films:
How We Know What We Know, 29 mins., b & w., sound. University of Indiana, AudioVisual, Bloomington, Ind. 47401
Sentence Variety and Grammar, 30 mins., b & w., sound. University of Indiana, AudioVisual, Bloomington, Ind. 47401

Instructional Materials:
Various auto-tutor machines, such as:
Welch Auto-tutor, Welch Scientific Co., 7300 North Linder Avenue, Skokie, Ill. 60076

3. Written Expression: Background and Resource Materials, General References

Baker, *The Complete Stylist*
Brooks *and* Warren, *Modern Rhetoric*
Hodges *and* Laws, *Harbrace College Handbook*
Morris, *Form and Forcus* (readings to illustrate types)
Taft *and* others, *The Technique of Composition*

Programed Materials:
Bergman, *Paragraph Rhetoric: A Program in Composition*
Blumenthal, *English 2600*
Blumenthal, *English 3200*
Everett *and* others, *An Auto-Instructional Text in Correct Writing*
Ferster, *Programed College Composition*
Hook, *Spelling 1500: A Program*
Hook *and* Stevens, *Competence in English: A Programed Handbook*
Palmer, *The English Sentence: A Programed Course*
Shurter *and* Reid, *A Program for Effective Writing*
Smith, *A Programed Text: Spelling by Principles*
Sullivan, *Programed Grammar*

Workbooks:
Sachs *and* others, *A Workbook for Writers*
Hodges *and* Laws, *Harbrace College Workbook*
Di Pippo, *From Sentence to Paragraph*
Willis, *Structural Grammar and Composition*

Teaching Machines:
Autotutor, The Welch Scientific Co., 7300 North Linder Avenue, Skokie, Ill. 60076

4. Improving Reading Efficiency: Background and Resource Materials

Reading Texts:
Brown, *Efficient Reading*
Canavan *and* Heckman, *The Way to Reading Improvement*
Canavan *and* King, *Developing Reading Skills*
Carter *and* others, *Effective Reading for College Students*
Judson, *The Techniques of Reading*
Leedy, *Read with Speed and Precision*
Sherbourne, *Toward Reading Comprehension*

Note—These are just a few of the many excellent texts in the field.

Vocabulary
Programed Material
Brown, *Programed Vocabulary*
Vocabulary Books
Brown, *Learning Words in Context*
DeVitis *and* Warner, *Words in Context*
Groom, *A Short History of English Words*
Richards *and* Romine, *Word Mastery*
Programs designed for reading machines:
Science Research Associates, Inc.
Craig Research, Inc.
Education Developmental Laboratories

5. Talking And Listening: Background and Resource Materials

Baird *and* Knower, *General Speech*
Capp, *How to Communicate Orally*
Crandell *and* others, Speech: *A Course in Fundamentals*
Freeley, *Argumentation and Debate*
McBurney *and* Mills, *Argumentation and Debate*
McCall *and* Cohen, *Fundamentals of Speech*
Monroe, *Principles and Types of Speech*
Oliver *and* others, *Communicative Speaking and Listening*
Rogge *and* Ching, *Advanced Public Speaking*

Principals of Social Science

Hours Required

Class, 3; Laboratory, 0

Course Description

This course consists of a practical approach to the nature of man and his behavior individually and in groups. The course stresses human relations: how man learns and fits into his group, community, culture, and nation.

The first part of the course is intended to acquaint students with the various fields in social science. The other parts of the course are intended to go into more depth covering the relationships between people, groups, and societies. The main objective should always be to point out how the student will fit into each situation.

The nature and needs of man including personality, maturity, and motivation should be related to getting along with or supervising people. The part showing how cultures and societies have developed and are organized should be related to his place and his responsibilities in society. How the student can develop responsible leadership in helping to bring about desired changes should be discussed in relationship to social problems.

The section on learning should relate to the student personally and to how people may be trained on the job. Actual job situations should be used as examples in class.

The part of the course related to government should be aimed at responsible citizenship. The student should learn what individual rights and responsibilities he has and how to properly exercise them by responsible political action.

Finally the student should be prepared to find his starting place in the world of work. He should be prepared for problems he will encounter and how to cope with them. His first step may be an interview for a job. He should prepare a brochure of his personal file to submit to employers. It is recommended that simulated job interviews be held in class using advisory committee members as employers. After the interviews, critiques should be held to discuss strong and weak points in the procedure.

The instructor should encourage students to ask questions at any time during class. This helps the instructor to know how well the material is being assimilated by students and what their problems may be.

There is not one textbook, at present, which would be entirely suitable for this class, so students should be assigned reading work in the library. Several good references are listed at the end of the outline. In addition, reprints from **Scientific American** or other such sources should be used.

Careful consideration should be given to choosing an instructor to teach this course. The teacher should have a broad background in the social sciences and, in addition, experience in work other than teaching. A teacher with these qualifications is more likely to have an empathy for the students and understand the problems they will be facing. These factors are as important as knowledge of the subject.

Major Divisions

		Class hours
I.	The Scope of the Social Sciences	6
II.	The Nature of Man	6
III.	Man and His Culture	9
IV.	Human Behavior	6
V.	The Learning Process	6
VI.	The Individual's Relationship to Government	6
VII.	The World of Work	9
	Total	48

Units of Instruction

I. The Scope of the Social Sciences
  A. Definition of the social sciences
    1. Sociology: the study of the social structure of contemporary complex societies.
    2. Anthropology: the study of human variation
    3. Psychology: the study of individual group behavior and experiences.
    4. Other fields
      a. Political science: the study of politics and government
      b. Economics and business: the study of production, distribution, and consumption of material goods and services fulfilling the needs of societies.
  B. The scope of sociology
    1. Human encounters
      a. Groups man forms
      b. Intergroup relationships
    2. Social structures
      a. Organizations and markets (leadership)
      b. Social stratification and social mobility
      c. The family: function, interaction, variations
      d. Cultures (social problems)
  C. The scope of anthropology
    1. The origin, development, and differentiation of man
      a. Man and the animals
      b. The criteria of human classification (physical traits)
      c. Classifying the races of modern man
    2. The concept of man's culture
      a. Culture is man's design for living

which governs the behavior of the members of that culture
      - b. Patterns of various cultures, ancient to present
- D. The scope of psychology
  - 1. Growth and development of the individual
    - a. Childhood
    - b. Adolescence
    - c. Adult years
  - 2. Motivation and emotional behavior
    - a. Motives that make the individual
    - b. The emotions and behavior
  - 3. Learning and thinking
    - a. How man learns
    - b. Creative thinking and problem solving
    - c. Testing and evaluating learning
  - 4. Mental health of the individual
    - a. The effect of heredity and environment
    - b. Personality factors
    - c. Adjustment to pressures and conflict
    - d. The abnormal individual (psychiatry)
  - 5. Applied psychology
    - a. Vocational selection and counseling
    - b. Family counseling
    - c. Studying interpersonal relations, attitudes, opinions, etc.

II. The Nature of Man

- A. Classification of men and animals
  - 1. Zoological classifiations
  - 2. Relationship between men and animals
- B. Chronological periods in history
  - 1. Archeozoic
  - 2. Proterozoic
  - 3. Paleozoic
  - 4. Mesozoic
  - 5. Cenozoic
- C. Modern man
  - 1. Criteria of human classification
    - a. Cranial vault
    - b. Face and lower jaw
    - c. Nose
    - d. Eyes, lips, ears
    - e. Skin, hair, eye color
    - f. Hair
    - g. Stature, weight, build
    - h. Blood groups
  - 2. Classification of modern man
    - a. Causacoid, mongoloid, and negroid races
    - b. Geographical races
    - c. Causacoid local races
    - d. Negroid local races
    - e. Mongoloid local races
    - f. Indian local races
    - g. American Indian local races
    - h. Specialized local
    - i. Emerging hybrid races
- D. Needs of man
  - 1. Physiological
    - a. Hunger
    - b. Thirst
    - c. Breath
    - d. Elimination
    - e. Fatigue
    - f. Temperature regulation
    - g. Pain avoidance
  - 2. Social drives
    - a. Sex
    - b. Activity
    - c. Maternal
    - d. Safety and security
    - e. Love and belonging
    - f. Esteem and self-esteem
    - g. Social aspects of self-actualization
- E. Personality development
  - 1. Definition of personality
  - 2. Shaping of personality
    - a. Effect of culture
    - b. Physique and temperament
    - c. Intellectual
    - d. Interests and values
    - e. Social attitudes
    - f. Motivational traits
    - g. Expression and style
    - h. Pathological traits
  - 3. Concepts of normality
  - 4. Growth and development
    - a. Early years
    - b. Adolescence
    - c. Maturity
  - 5. Mechanisms of defense and mastery
    - a. Frustrations
    - b. Adjustment to environment
  - 6. The motivation process
    - a. Determine objective
    - b. Develop empathy
    - c. Communicate

        - d. Establish relationships
        - e. Furnish proper tools

- III. Man and His Culture
  - A. Nature and meaning of culture
    - 1. Cultural evolution
      - a. Education
      - b. Cultural lag
  - B. Origin of cultures
    - 1. Primitive man
    - 2. Family groups
    - 3. Early political organizations
  - C. Development of culture
    - 1. Religion
    - 2. Art
    - 3. Language
  - D. Modern culture
    - 1. The family group
      - a. Social-psychological function
      - b. The agrarian family
      - c. The industrial family
      - d. Marriage and mating
      - e. The changing family role
    - 2. Socialization
      - a. Forming groups
      - b. The individual and his groups
        - (1) Characteristics and functions
        - (2) Limits on size and organization
        - (3) Group dynamics
        - (4) Social and Religious values
    - 3. The community
      - a. Origin
      - b. Characteristics and growth
      - c. Rural-urban balance
      - d. Class structure
      - e. Social stratification
      - f. Social agencies in the community
      - g. Needed changes
    - 4. Societies and groups
      - a. Types
        - (1) Social
        - (2) Labor unions
        - (3) Management
      - b. Social controls
      - c. Functions
    - 5. Social controls
      - a. Formal
      - b. Informal
    - 6. Collective behavior
      - a. Social changes
      - b. Social movements
    - 7. Group leadership
      - a. Innovators
      - b. Followers or adaptors
      - c. Responsibilities
    - 8. Social problems
      - a. Population growth
      - b. Land use
      - c. Communications
      - d. Transportation
      - e. Wars
      - f. Food supply
      - g. Rural-urban migration
      - h. Rural development
      - i. Poverty and welfare
      - j. Technological change
      - k. Automation

- IV. Human Behavior
  - A. Background
    - 1. Cultural
    - 2. Biological
  - B. Heredity
    - 1. Genetic basis
    - 2. Phenotypes and genotypes
    - 3. Population genetics
    - 4. Heredity in animal behavior
    - 5. Physically and mentally handicapped workers
  - C. Environment
    - 1. Effect on individual
    - 2. Overcoming environmental handicaps
  - D. Behavior of people
    - 1. Why people behave as they do
    - 2. Relationship to personality development
    - 3. Factors influencing changing of behavior
    - 4. Problems of maturation
  - E. Leadership
    - 1. Followership
    - 2. Leadership traits

- V. The Learning Process
  - A. Intelligence
    - 1. Definition
    - 2. How developed
  - B. Perception
    - 1. Motivation
    - 2. Action
    - 3. Learning and performance
  - C. Cognition
    - 1. Memory

        2. Language
        3. Meaning
        4. Reasoning
        5. Problem solving
    D. Insight
        1. Readiness
        2. Mental set
    E. Transfer of training
        1. Identical components
        2. Application of principles
    F. Memory and retention
        1. Forgetting
        2. Overlearning
        3. Repression
        4. Recognition and recall
    G. Practical implications
        1. Use in training workers
        2. Use in hiring personnel
        3. Use in assigning workers at jobs
        4. Use in evaluating success

VI. The Individual's Relationship to Government
    A. Individual and politics
        1. Local, State, national
        2. Political Parties
        3. Rights
        4. Responsibilities
    B. Voice in Congress
        1. How attained
        2. Responsible actions
            a. Pressure groups
            b. Public opinion
            c. Propaganda
    C. Laws affecting private enterprise
    D. Rural-urban interdependence
        1. Conflicts
            a. Social
            b. Economic
        2. Solutions to problems
    E. Public policy formation
        1. Individual
        2. Legislative
        3. Judicial
        4. Executive

VII. The World of Work
    A. Planning your future
        1. Physical limitations
        2. Educational limitations
        3. Personal traits and job success
    B. Selling yourself
        1. Strong points
        2. Weak points
        3. Personal brochures
        4. Job interview techniques
        5. Actual job interviews
    C. Assuming responsibility
        1. Self improvement
        2. Self management
    D. Interpersonal relationships
        1. Personal problems
            a. Stress or conflict
            b. Troubled personality
            c. Emotions
        2. Self and projected image
        3. Race and ethnic relations
    E. Supervising others
        1. Human relations
        2. Job orientation
        3. Teamwork
        4. Job oriented problems
        5. Personal problems
        6. Motivating others
        7. Communication

Texts and References

Bain, *Sociology: Introductory Readings*
Bass, *Leadership, Psychology, and Organizational Behavior*
Beals *and* Hoijer, *An Introduction to Anthropology*
Bellows, *Psychology of Personnel in Business and Industry*
Davis, *Human Relations at Work*
Gilmer, *Applied Psychology*
Hathaway, *Government and Agriculture*
Hilgard, *Introduction to Psychology*
Kalish, *Psychology of Human Behavior*
Krech *and* others, *Individual in Society*
Mott, *The Organization of Society*
Slocum, *Agricultural Sociology*
Taylor *and* Jones, *Rural Life and Urbanized Society*
White *and* others, *Sources of Information in the Social Sciences*

BUILDINGS, FACILITIES, EQUIPMENT, AND COSTS

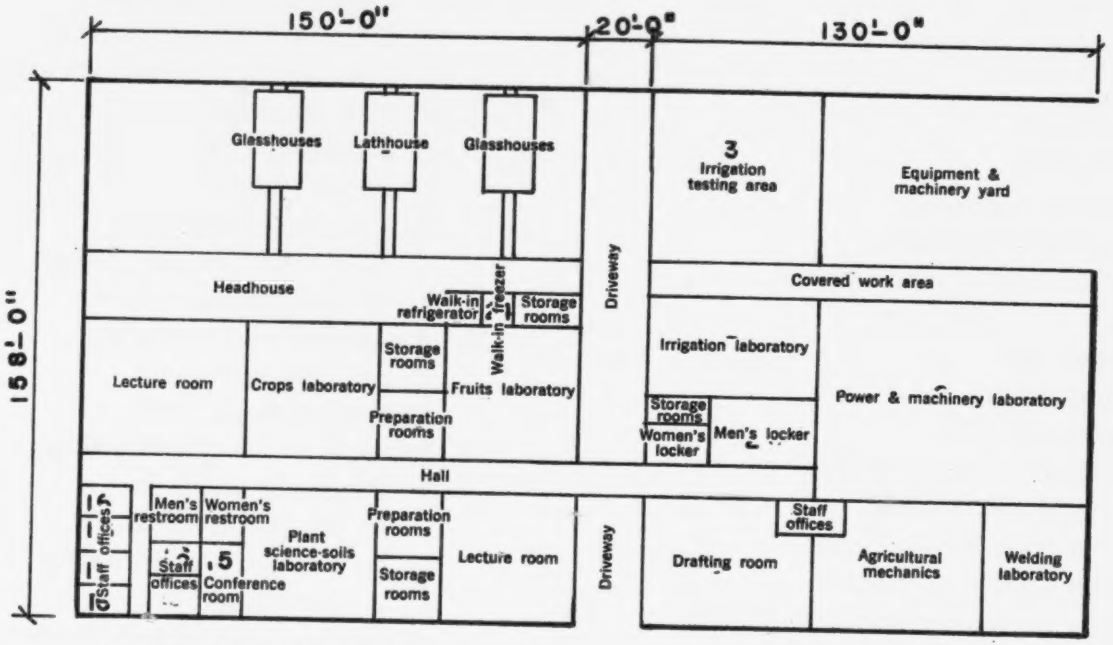
150'-0"
20'-0"
130'-0"
158'-0"
Glasshouses
Lathhouse
Glasshouses
3
Irrigation testing area
Equipment & machinery yard
Driveway
Headhouse
Walk-in refrigerator
Walk-in freezer
Storage rooms
Covered work area
Lecture room
Crops laboratory
Storage rooms
Fruits laboratory
Preparation rooms
Irrigation laboratory
Storage rooms
Women's locker
Men's locker
Power & machinery laboratory
Hall
Staff offices
Men's restroom
Women's restroom
Staff offices
5
Conference room
Plant science-soils laboratory
Preparation rooms
Storage rooms
Lecture room
Driveway
Staff offices
Drafting room
Agricultural mechanics
Welding laboratory

Figure 24.—An example of a plan for facilities for a farm crop production technology program.

A most important part of planning any curriculum is the consideration of buildings, facilities, equipment, and costs. Administrators, staff, and advisory committees should keep the educational needs described in this guide in mind when planning facilities. Failure to do so can easily result in facilities that are either inadequate or too elaborate to provide optimum instruction.

General Planning

The guidelines that follow are intended as a general guide to groups planning facilities to offer either option in field and forage crops or fruit and vine production or both. It is assumed that facilities for general education and chemistry already exist on the campus. Therefore, the suggestions offered in this guide apply only to those facilities and equipment which will be needed for the technical and supporting courses suggested in the curriculum.

In addition, this guide is concerned only with the two options discussed in the first part of this study. When planning facilities, serious consideration should be given to other agricultural programs that may be offered. For example, the curriculum in field and forage crops could combine very well with one in ornamental horticulture or one in agricultural equipment technology. Much of the equipment and laboratories could be utilized in both or all three curriculums. Indeed they should be to justify the cost of the facilities. The same principle might apply to animal husbandry or grain, feed, seed and farm supply technology programs. However, those planning any combinations of curriculums should bear in mind that even though some equipment can be used for other curriculums, the facilities suggested in this guide are needed for the farm crop production technology program and some of the facilities required for other curriculums may have to be in addition to these. Additional space might be needed for demonstration plots and greenhouses, for example, for an ornamental horticulture program.

Since some schools may offer only one of the options presented in this guide, the breakdown of facilities, equipment, and costs are shown separately for each option, and what they would be for both. Some of the recommended equipment would be common to either option.

The planning of buildings and facilities should always include some provision for growth. It is recommended that classroom facilities be close enough to the rest of the campus to be an integral part of it and to allow adequate passing time between classes. If the

campus complex, this can allow demonstration plots and the shop facility, where equipment is used, to be far enough away to reduce any noise disturbance and to allow room for expansion. Planning should provide for at least 10 years of future growth and development.
facility is located on the edge of the main

Land Requirements

In addition to the land needed for the classroom, greenhouse, and shop facilities it is very desirable that there be 50 to 100 acres provided for orchard and demonstration plots. At least 25 acres should be considered a **minimum.** This should include 5 to 10 acres of land adjacent to the greenhouses for a nursery plot. In addition, about 5 to 10 acres each should be provided for demonstration orchard and crop test plots.

The allocation of space in the orchard could vary according to the leading fruit and nuts crops of the area but might be as follows: 3 acres of the leading fruit or nut crop of the local area, 1 acre of variety plots of fruit and nuts, and 1 acre of grapes, bush berries, or other small fruit. An area of at least this size is needed to demonstrate cultural practices including irrigation and weed and pest control.

The crop area may be used for one crop or a combination of rotation of crops according to local farming conditions. The combination of crop and orchard acreage should be ample to allow for the use of various kinds of farm machinery.

When selecting the land for the orchards and test plots, careful consideration should be given to obtaining land that is suitable for demonstration use including irrigation. The land should be reasonably level, well drained, and fertile. If the land cannot be purchased, a long term lease should be explored.

Building Facilities

The minimum building facilities needed to offer both options in field and forage crops and fruit and vine production are as follows:

1 crops laboratory
1 fruit laboratory
1 soils laboratory
1 small lecture room
1 large lecture room
2 storage and preparation rooms
5 offices
1 conference room
1 headhouse
2 glasshouses
1 lath house
1 shop (including storage shed)
1 drafting room
1 irrigation laboratory

A plan showing an example of an arrangement of facilities is shown in figure 24. If only one option is offered, one laboratory and one classroom could be omitted as well as one office and one greenhouse.

It is recommended that some consideration be given to a building without windows. One of this type makes heating and air conditioning and darkening for audiovisual use easier to control and often more economical. Special planning should be exercised to make use of space most flexible by movable walls and by using postable equipment whenever possible.

When a building is planned, conduit for closed circuit television or other types of teaching aids which may be used should be included. Even though these teaching aids may be contemplated for future use, it is cheaper to install the necessary conduit or electrical floor outlets during initial construction. Air conditioning or suitable environmental control for the climate should be considered in preparation for eventual year-round operation of the school.

There should be special planning for audiovisual equipment such as motion picture, slide, and overhead projectors in classrooms or laboratories where they may be used. Convenient location of electrical outlets which are the proper distance from the screen location is necessary. Ceiling height and lighting equipment should be high enough to allow for projection screens. Switches to control the lights and screen from the projector location are desirable. In both classrooms and laboratories it is sometimes desirable to have students take notes during the showing of films or slides. Special low intensity lighting should be provided for this purpose.

Lighting in classrooms and laboratories should be a minimum of 50-foot candles at desk top with a minimum of shadow. Several different types of lighting may be used to attain this result.

Any technical program of the type suggested here requires many types of small equipment, models, and other teaching aids. For this reason adequate storage space should be provided where equipment is accessible but out of sight when not in use. Laboratories are usually planned to serve also as classrooms, so that it is desirable to have equipment put away while other classes use the room. Storage areas should be planned with easy access to the outside to facilitate the delivery of supplies and equipment.

Planning the Laboratories

Hot and cold water and gas are required in all laboratories in addition to both 110- and 220-volt electrical service. The necessary requirements for each laboratory are discussed later.

Outside telephone lines should be included in the offices, shop, and laboratories with an intercom system between classrooms.

The **HEADHOUSE** area should be planned as a headhouse as well as an enclosed work area (see figure 24). There will be times when classes want to work with pesticides, fertilizers, or soils, and it is desirable to move out of the classroom. The headhouse area serves this purpose. The amount of protection from the weather should be dictated by the prevailing climate of the region. In addition, at least a part of the area should be enclosed with fencing for security purposes. The covered headhouse area should also include storage bins for sand and soil mixes and storage for clay flower pots.

A walk-in deep freeze and refrigerator should be provided in the enclosed area of the headhouse. These are desirable for storing plant materials and fruits or vegetables for later laboratory use.

In the event that only the crop option is offered, the fruit laboratory and small lecture room could be deleted from the building plans. In the estimates which follow, costs are given for either one or both options.

The **CROPS LABORATORY** is shown in figures 25, 26, and 27. The laboratory tables provide for 24 student work stations with an electrical outlet at each station. One side of the laboratory is equipped with sinks and molded sink tops as a work area for using liquids. Gas and electrical outlets should be available at this area. The space under the sink area is equipped with storage cabinets for equipment.

The crops laboratory should contain a drying cabinet for plant collections and specimens as well as a herbarium for plant and seed storage. Mercury lined herbariums are desirable to prevent insect infestation.

The student tables should have acid resistant

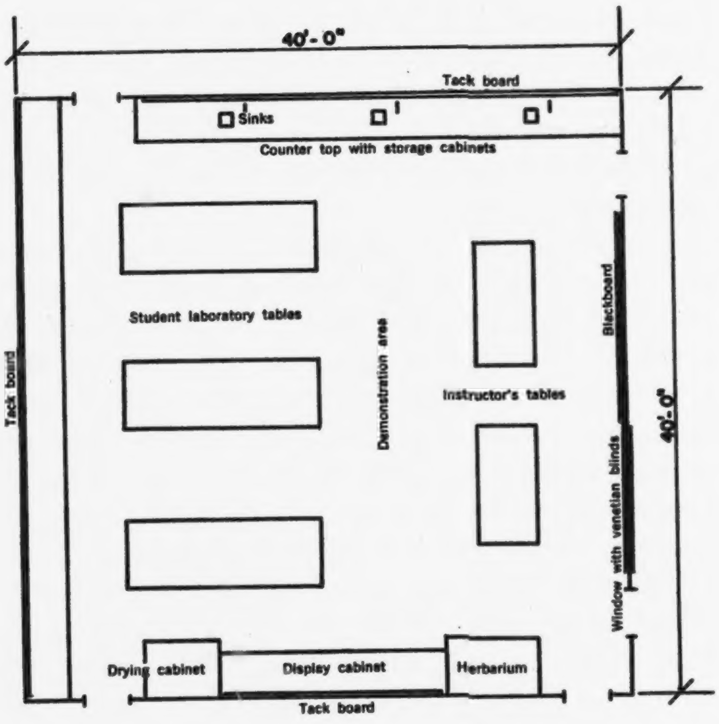

Figure 25.—Crops Laboratory.

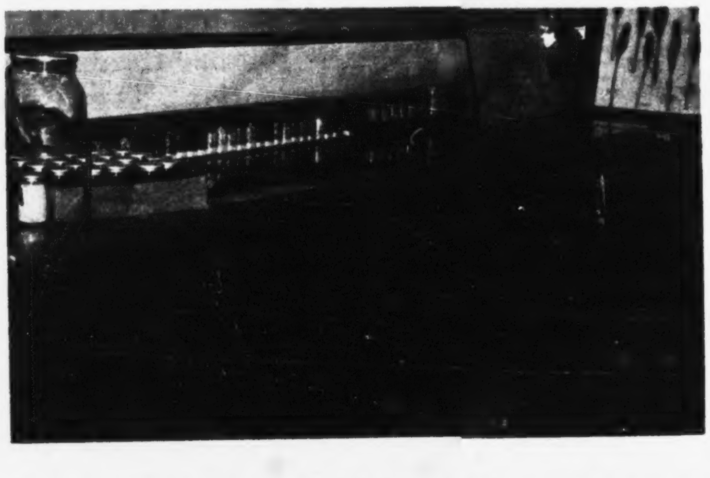

Figure 26.—This display case with interchangeable drawers and a glass top is an effective way to display agricultural products in a farm crop laboratory.

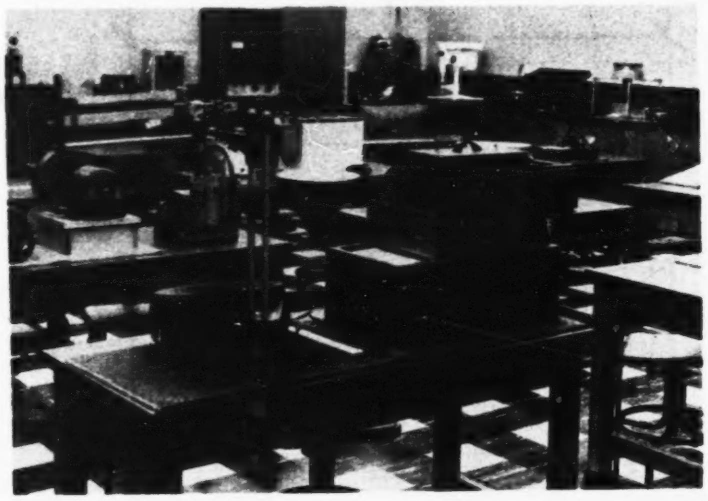

Figure 27.—Equipment for an agricultural production testing laboratory should be selected to provide maximum mobility whenever possible so it can be brought to the laboratory tables when needed but placed in storeroom when not in use.

tops but acid sinks and plumbing need not be included because they are provided in the plant science-soils laboratory.

Drawers along the wall between the herbarium and drying oven should be of various sizes for storing seeds and other teaching aids. The top may be covered with glass to provide a display area in the top drawers. This allows for displays without having the specimens out on top of the cabinet. If the glass top is used, it should be specially lighted to allow specimens to be seen well. The drawers should be the same size and interchangeable to permit easy changing of displays.

The instructor's station should consist of two movable cabinets. One should have drawers and cabinets in it for storage. The other should have shelves; it should be small enough to be rolled into the storage or preparation room where laboratory materials are readied. This allows the instructor to arrange demonstration materials and put them on the cart in the preparation room while another class uses the laboratory. He can then roll the cart into the laboratory before class begins and have all of his materials ready to use.

By using movable laboratory tables, a demonstration area can be provided in the laboratory for demonstrating and using the various kinds of equipment. If apparatus such as hammer mills, seed separators, and equipment of that kind is mounted on casters, moving the units back and forth from storage to classroom is easier.

Space for tackboard and blackboard should be provided. Sliding blackboards over stationary ones can be used to provide extra blackboard space.

The **FRUIT LABORATORY** can be planned very much the same as the crops laboratory. The drying oven and herbarium may be eliminated and this space used for storage. (see figure 29)

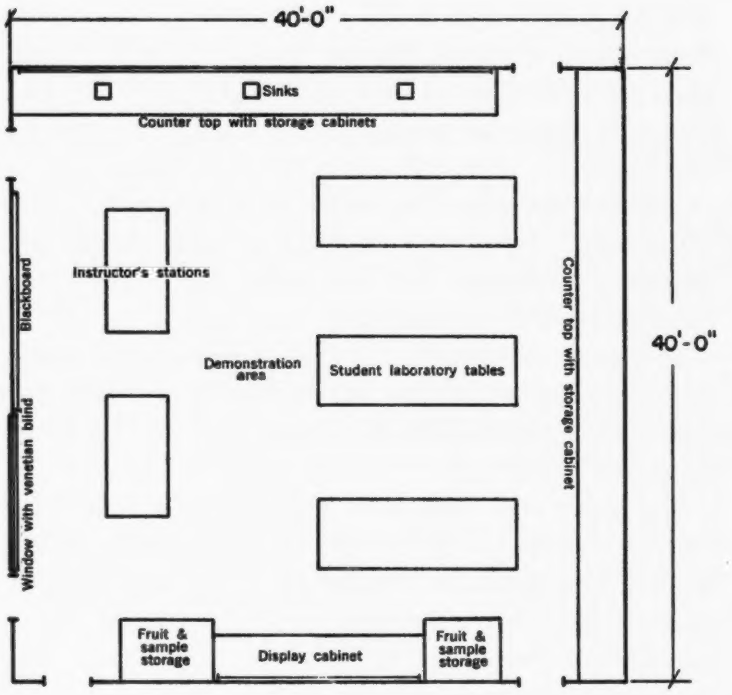
40'-0"
Sinks
Counter top with storage cabinets
Blackboard
Window with venetian blind
Instructor's stations
Demonstration area
Student laboratory tables
Counter top with storage cabinet
40'-0"
Fruit & sample storage
Display cabinet
Fruit & sample storage

Figure 28.—Fruit laboratory.

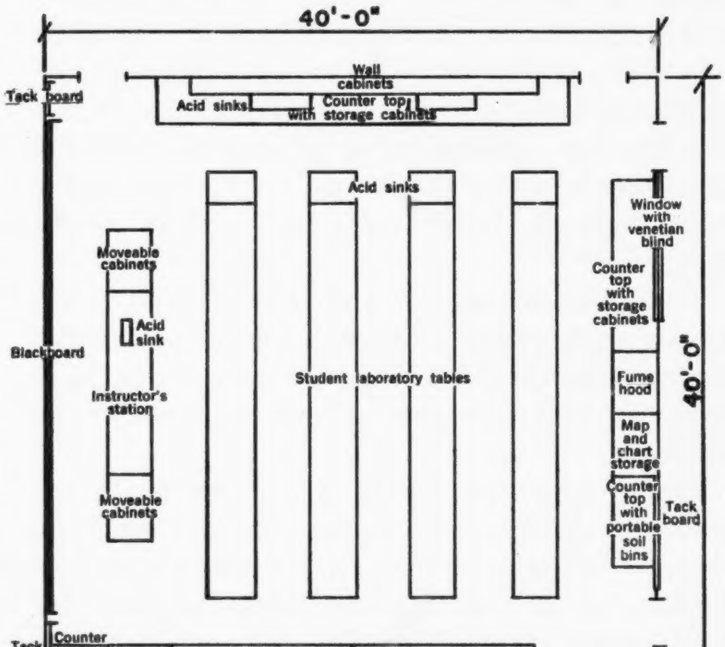
40'-0"
Tack board
Wall cabinets
Acid sinks
Counter top with storage cabinets
Acid sinks
Moveable cabinets
Acid sink
Blackboard
Instructor's station
Moveable cabinets
Student laboratory tables
Window with venetian blind
Counter top with storage cabinets
Fume hood
Map and chart storage
Counter top with portable soil bins
Tack board
40'-0"
Tack board
Counter top with portable soil bins
Map and chart storage
Acid sinks
Counter top with portable soil bins
Tack board

Figure 29.—Soils laboratory.

The **PLANT SCIENCE AND SOILS LABORATORY** may be planned to serve as a teaching laboratory for crop botany, soils, soil management, and some of the irrigation and water management laboratory experiments. (see figure 29)

The tables are arranged differently in this laboratory and include acid sinks at the end of each table. Table tops should be acid resistant because most exercises involving the use of acid will be conducted in this laboratory. Each student work station should have electricity and gas, in addition to gas and electricity at the sinks in the laboratory tables along the side of the room.

Since acid may be used extensively in this laboratory, it should include a fume hood and safety equipment. An eye bath and emergency shower should be provided.[1]

At least one cabinet in this laboratory should include chart storage for soil maps. Long flat drawers which allow the maps to be laid out flat during storage are desirable.

Portable soil bins that resemble the cabinets can be made to fit under the sinks along the side. These provide a place to store soil samples out of sight in the classroom. By having them on casters they can be wheeled to the door for ease in filling or emptying.

STORAGE AND PREPARATION ROOMS are shown in figures 30, 31 and 32. The preparation rooms can be used by students and instructors. They are located between the laboratories or demonstration and lecture room, (see figure 24) and are glassed in so that student activities may be observed by the instructor. Venetian blinds can be provided so windows can be darkened.

The preparation rooms should have sinks for cleaning glassware and other laboratory equipment. Sinks should contain commercial garbage disposal units to dispose of plant materials from the labs.

The preparation room B, off of the plant science and soils laboratory, should include an area for balances. Due to the delicate characteristics of these instruments, a special base for them should be provided. Ordinary cabinets permit too much vibration to provide required accuracy in the use of the most precise balances.

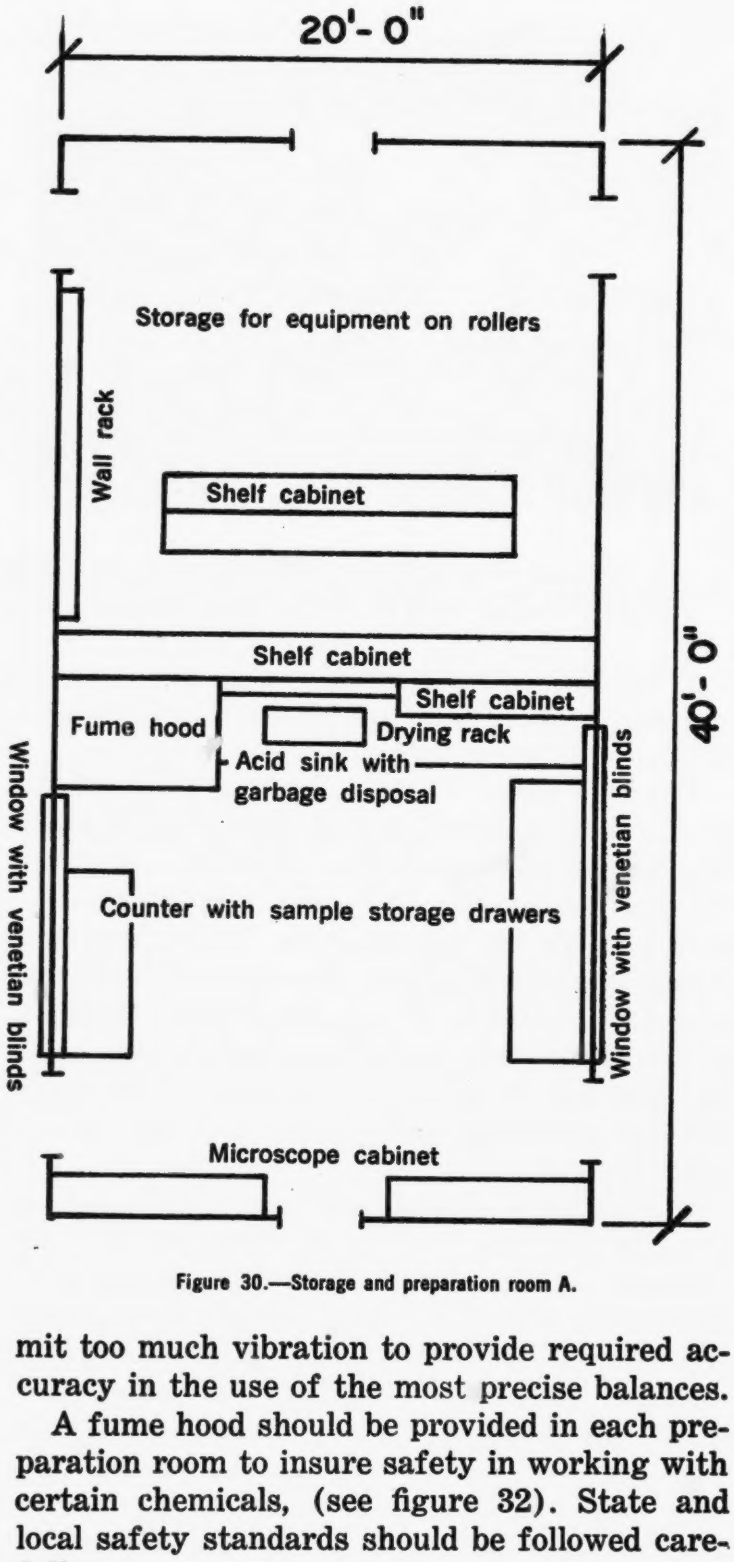
20'- 0"
40'- 0"
Storage for equipment on rollers
Wall rack
Shelf cabinet
Shelf cabinet
Shelf cabinet
Fume hood
Drying rack
Acid sink with garbage disposal
Window with venetian blinds
Window with venetian blinds
Counter with sample storage drawers
Microscope cabinet

Figure 30.—Storage and preparation room A.

A fume hood should be provided in each preparation room to insure safety in working with certain chemicals, (see figure 32). State and local safety standards should be followed carefully.

The storage rooms should open to the outside for ease of making deliveries of supplies and equipment. They should be well lighted and have a variety of shelf and cabinet sizes.

A storage cabinet which can be kept locked should be provided for microscopes. Microscopes can be kept in both preparation rooms, but each scope should have a marked storage space which corresponds with its serial number.

---

[1] See *Chemical Technology, a Suggested 2 Year Post High School Curriculum*, published by the Department of Health, Education and Welfare, OE—80033, for discussion of laboratories.

Missing scopes are more easily identified using this system.

Figures 33 through 36 show the layout of the shop, drafting laboratory, irrigation laboratory, and greenhouses.

It is highly desirable to have a paved, well drained area adjacent to the shop building. This provides a place to receive and store heavy materials such as sand, soil, peat moss, fertilizers, pesticides, repair parts, and such supplies as well as to load and unload equipment. If part of such an area can be roofed so much the better. An outdoor work area with good drainage, a solid work surface, and protected from wind, rain, and sun is particularly useful.

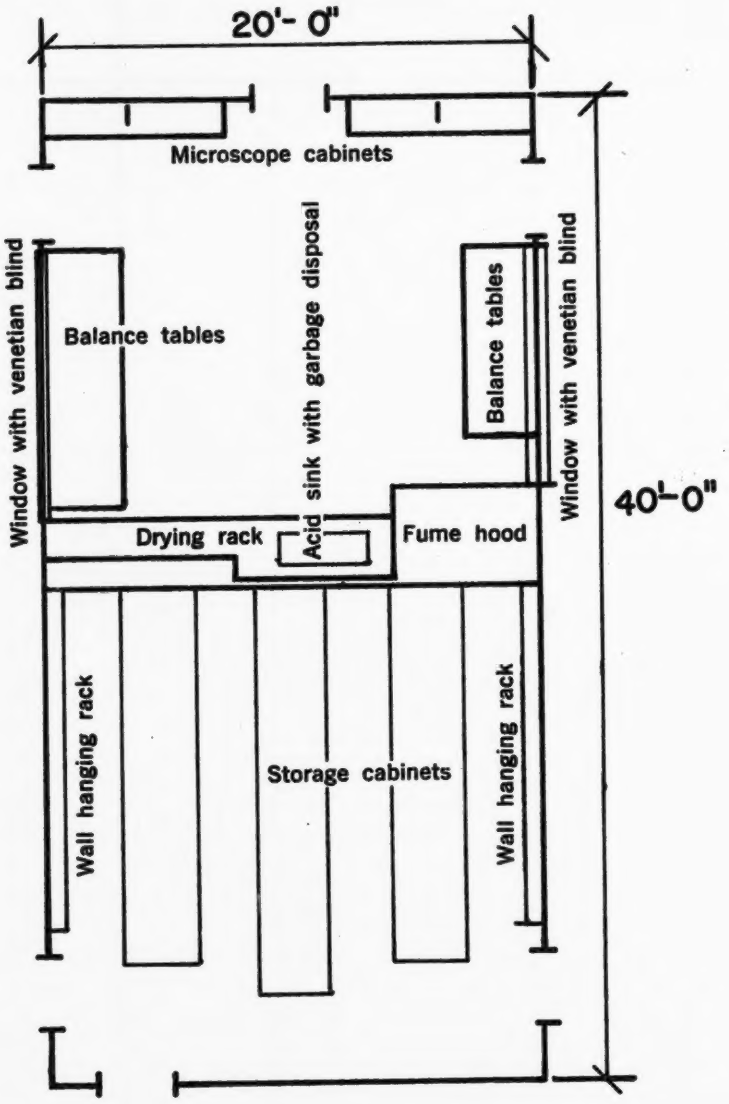
20'- 0"
Microscope cabinets
Window with venetian blind
Balance tables
Acid sink with garbage disposal
Balance tables
Window with venetian blind
40'-0"
Drying rack
Fume hood
Wall hanging rack
Storage cabinets
Wall hanging rack

Figure 31.—Storage and preparation room B.

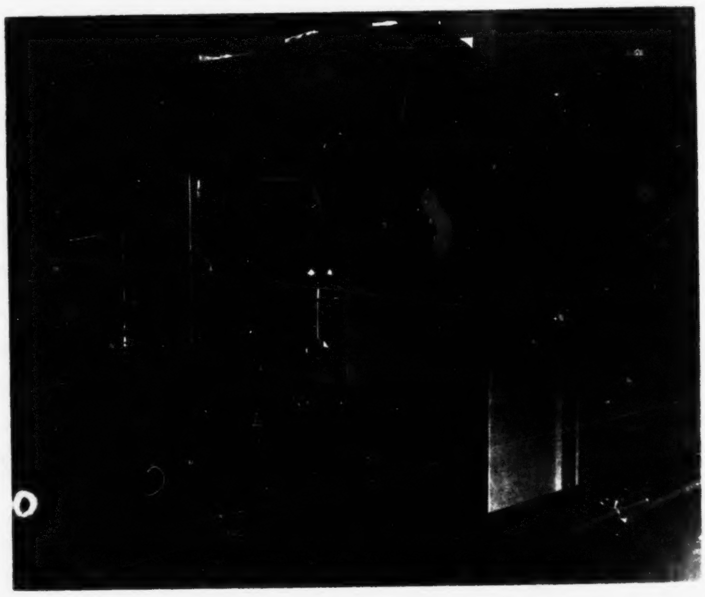

Figure 32.—A preparation room where instructors can store and prepare laboratory materials is very desirable. (See fig. 24.) Note fume hood in foreground, walk-in cooler to right, and chemical storage, shelving and work area in left background.

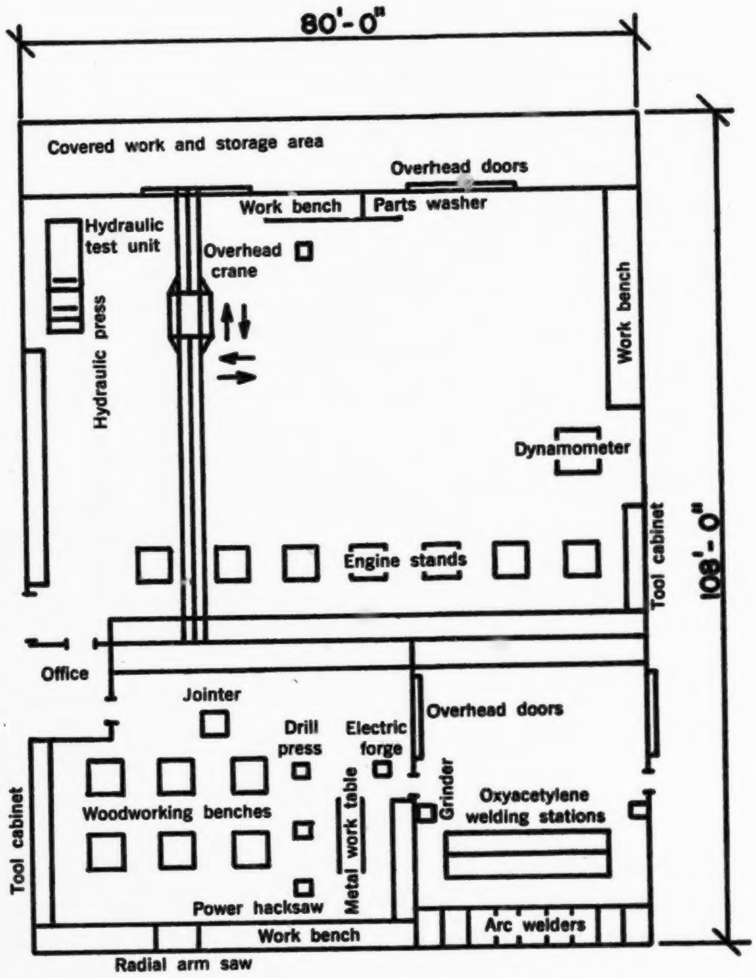
80'-0"
Covered work and storage area
Overhead doors
Work bench
Parts washer
Hydraulic test unit
Overhead crane
Hydraulic press
Work bench
Dynamometer
Engine stands
Tool cabinet
108'-0"
Office
Jointer
Drill press
Electric forge
Overhead doors
Grinder
Oxyacetylene welding stations
Woodworking benches
Metal work table
Tool cabinet
Power hacksaw
Work bench
Arc welders
Radial arm saw

Figure 33.—Power and mechanics laboratory and shop.

Acquisition of Equipment, and Estimated Costs

The need to have adequate facilities and equipment for Farm Crop Production Technology programs has already been emphasized. The initial cost of facilities and equipment is a ma-

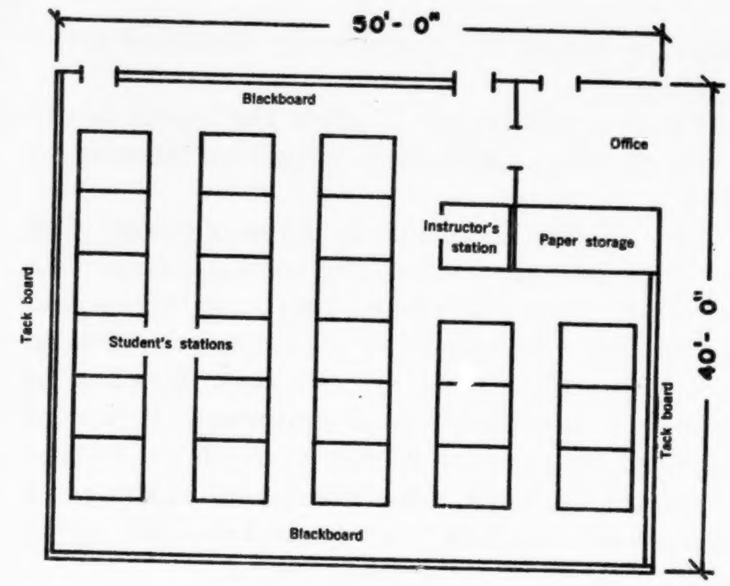
50'- 0"
Blackboard
Office
Instructor's station
Paper storage
Tack board
Student's stations
40'- 0"
Tack board
Blackboard

Figure 34.—Drafting room.

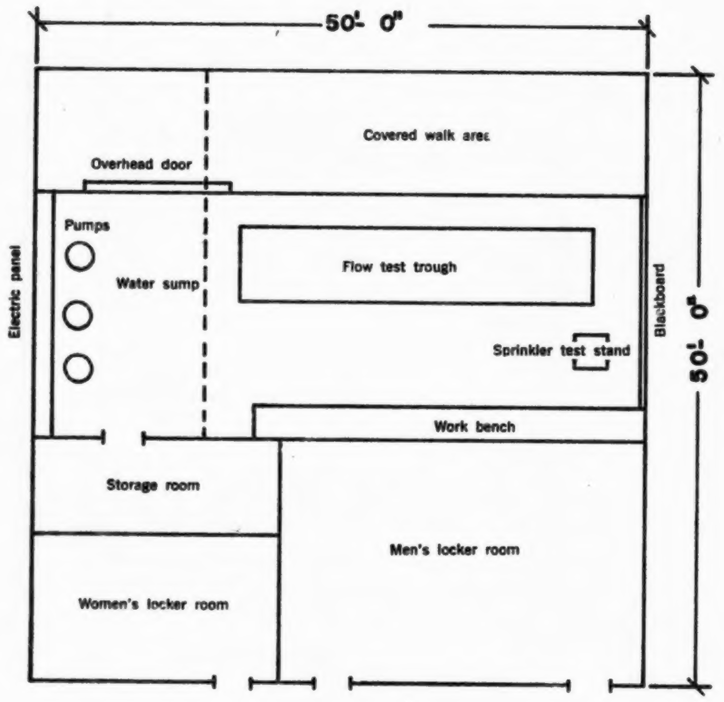
50'- 0"
Covered walk area
Overhead door
Pumps
Water sump
Flow test trough
Electric panel
Blackboard
Sprinkler test stand
50'- 0"
Work bench
Storage room
Men's locker room
Women's locker room

Figure 35.—Irrigation laboratory.

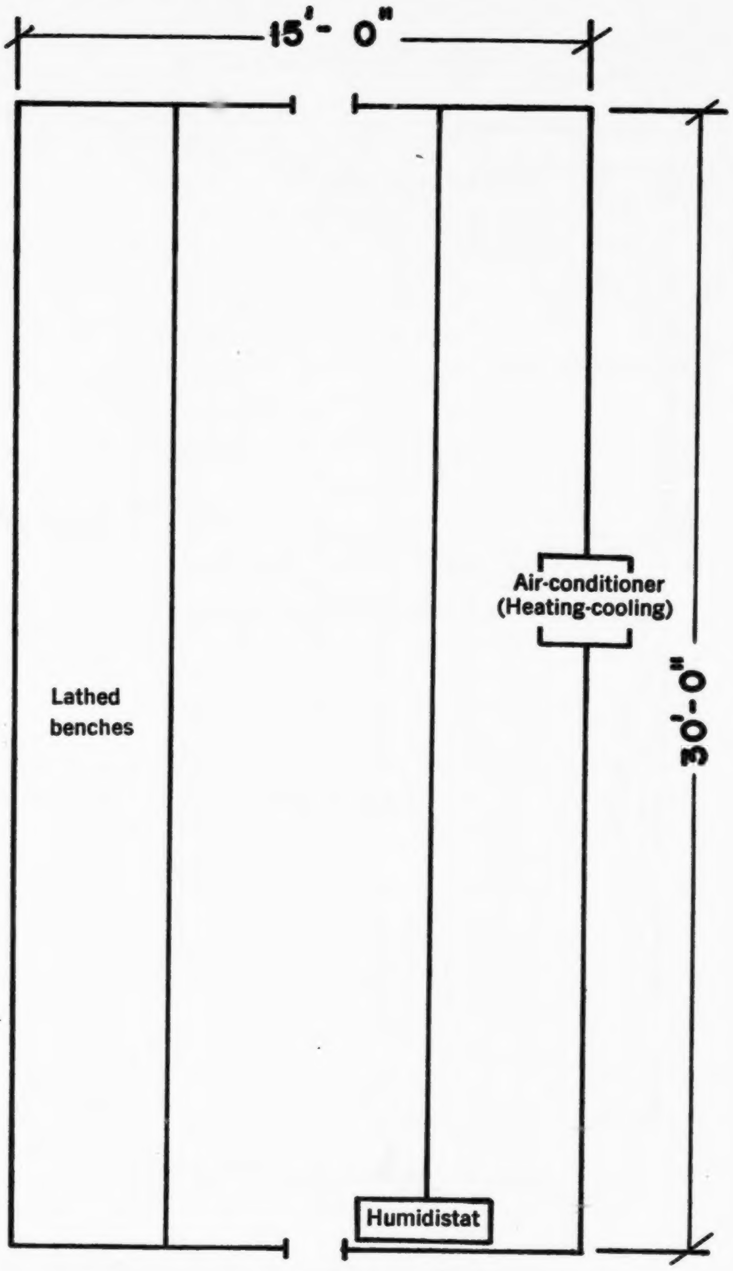
15'- 0"
Air-conditioner
(Heating-cooling)
Lathed
benches
30'-0"
Humidistat

Figure 36.—Greenhouse.

jor expenditure. The importance of using the combined expert knowledge of the (a) local advisory committee which advocates and supports the program, (b) the best available advice from consultants who are a part of an existing and successful program, and (c) the technical knowledge of the head of the Farm Crop Production Technology program being planned cannot be overemphasized when plans and estimates of costs of facilities are made. Each program and its total facilities will be different from others because of local or regional employment opportunities, climatic differences, and many other factors.

Specific facilities and equipment for any program should be acquired only after specialists who are technically competent in the field have made exhaustive studies of the plans and potential suppliers of materials and services. The department head who will be responsible for the program should be deeply involved and carry the major responsibility for final planning and acquisition of facilities and equipment. This will avoid costly mistakes which often result if non-technical personnel attempt to plan and equip technical program facilities.

There are many sources of equipment that should be explored in an effort to equip the program with up-to-date, adequate machinery and apparatus at a minimum cost. Surplus equipment, from either private or public organizations, can be an important source of good materials and hardware for equipping laboratories. Government surplus property may often be an especially attractive source of either standard or specialized units, apparatus, instruments, and equipment; the cost of which usually is only a small fraction of the cost when new. Educational institutions are high on the priority list of agencies to which government surplus property is made available.

Distribution of surplus property within the States is made through State agencies for surplus property. Most such State agencies maintain one or more distribution centers at which authorized representatives of eligible schools or school systems select materials for educational use. The Director of Vocational and Technical Education in each State can provide specific information on the location of the government surplus property distributing agency in his State.

Experience has shown that it is important to exercise the same elements of judgment and care in acquiring surplus equipment as is used buying new equipment. Specific plans for the use, and sound justification for the need should clearly be established for any price of surplus equipment; a careful analysis should be made of its total effectiveness in the program; its cost including initial cost, transportation, space required, cost of installation, repair or tune-up (if incomplete), and maintenance, and its pertinence in terms of obsolescence.

Only technically competent, responsible, and imaginative persons should select surplus equipment, and then only after a thorough on-site inspection. This practice avoids the temptation to acquire attractive but obsolete, irrelevant, or excessive amounts of equipment. With these precautions in mind, resourceful department heads or instructors can often obtain instruments, apparatus, and other essential up-to-date equipment for their laboratories and shops at a very reasonable cost.

Another source of equipment which is of great importance are farm equipment dealers. Often equipment can be rented or leased and used for the program until it is superseded by new models, at which time new leased equipment can take its place and thus keep the instructional equipment up-to-date. There is often a financial incentive to keep equipment which has been purchased outright beyond its technological usefulness.

Short term leasing of some equipment, such as spraying units or harvesting machinery, often is much less expensive than owning the equipment.

The suggested equipment for laboratories, shops and facilities listed on the following pages is rather extensive. Careful consideration has been given to the various types of units and amounts of equipment shown and the contributions of each to the educational program. It represents a list considered adequate for either of the options or for both, as indicated. Cost estimates shown are representative of those prevailing when this guide was published and may vary from 10 to 20 percent from one region or community to another.

Suggested Audiovisual Equipment

2	16 mm. motion picture projectors with tables
1	2- by 2-inch slide projector
1	filmstrip projector
1	slide stacker
1	slide tray with cabinets
1	tape recorder
1	35 mm. camera with attachments
5	movie screens
1	overhead projector

Estimated total cost: $2,500 to $3,000.

Suggested Laboratory Equipment

Quan.	*Item*	*Fruit option*	*Crops option*	*Fruit and crops option*
1	acreage wheel	X	X	X
1	analyzer, protein, Udy	----	X	X
1	aspirator, laboratory, Bates	----	X	X
1	autoclave	X	----	X
1	barometer	X	----	X
2	balances, analytical, Mettler	X	X	X

1	balance, grain inspection and dockage	....	X	X
1	balance, moisture determination, Ohaus	X	X	X
2	balances, single pan analytical	X	X	X
1	balance, specific gravity	X	....	X
1	balance, top loading, Mettler	X	X	X
6	balances, triple beam	X	X	X
2	blenders, food	X	X	X
1	broadcaster, hand seed	....	X	X
1	caliper, tree	X	....	X
1	can shear	X	....	X
4	chains, 100′ (steel tape)	X	X	X
6	clippers, fruit	X	....	X
4	colony counters	X	....	X
5	color comparator discs, Munsell (sets)	X	X	X
1	colorimeter, reflectance, Agtron	X	X	X
1	colorimeter, spinning disc	X	X	X
1	colorimeter, transmittance	X	X	X
1	color standards, (complete set), Munsell	X	X	X
1	corn breakage tester	....	X	X
1	cotton gin, laboratory type	....	X	X
1	cotton percenter	....	X	X
1	cotton tester, micronaire	....	X	X
12	cylinders, soil testing for use with soil dispersion mixer	X	X	X
2	dessicators	X	X	X
1	dockage tester, Carter	....	X	X
1	duster, bellows type, hand	X	X	X
1	environmental chamber	X	X	X
1	flow meter	X	X	X
12	funnels, separatory	X	....	X
1	furnace, muffle	X	X	X
1	germinator, Mangelsdorf	X	X	X
6	grafting tools	X	—	X
1	grafting wax melter	X	....	X
1	grain shaker-sizer	....	X	X
1	grain viewer and black light	....	X	X
1	grinder, food	X	....	X
1	grinder, Tag-Heppenstall electrode units	....	X	X
2	hot plates	X	X	X
1	hydrometer (lot)	X	....	X
1	hygrometer	X	....	X
1	incubator, Bacteriological	X	....	X
1	injector, chemical	X	X	X
1	injector, liquid fertilizer	X	X	X
12	illuminators, microscope	X	X	X
6	ladders, picking, 8′	X	....	X
6	ladders, picking, 12′	X	....	X
1	ladder, step, 8′	X	....	X
1	lamp, ultraviolet	X	....	X
4	levels, Abney	X	X	X
4	levels, Dumpy with tripods	X	X	X
6	levels, hand	X	X	X
12	magnifiers, illuminated	X	X	X
12	microscopes, binocular with illuminators	X	X	X
12	microscopes, dissecting	X	X	X
1	mill, laboratory, Steinlite	X	X	X
1	mill, laboratory, Wiley	....	X	X
1	miller, rice, McGill	....	X	X
4	mixers, soil dispersion	X	X	X
24	moisture indicators, tensiometers	X	X	X
4	moisture meters	X	X	X
1	moisture tester, Brabender with scale	X	X	X
1	moisture tester, Brown-Duvel	....	X	X
1	moisture tester, dried fruit	X	....	X
1	moisture tester, Motomco	....	X	X
1	moisture tester, Steinlite for grain	....	X	X
1	moisture tester, Steinlite for oil bearing seeds and nuts	X	X	X
1	moisture tester, Steinlite for processed fruits and vegetables	X	X	X
1	oil tester, Steinlite	X	X	X
12	orchard heaters	X	....	X
1	oven, laboratory, forced air draft	X	X	X
1	oven, vacuum	X	....	X
1	pearler, barley	....	X	X
6	penetrometers	X	X	X
2	pH meters	X	X	X
6	pH test kits, La Motte-Morgan Chemical type	X	X	X
1	picking ring for fruit (complete lot)	X	....	X
12	pruners, hand, vine	X	....	X
6	pumps, cut-aways of various types	X	X	X
24	purity workboards for seeds	....	X	X
4	rain gauges	X	X	X
4	range poles	X	X	X
1	refractometer, Abbe	X	....	X
1	refractometer, 0–25 percent	X	....	X
1	refractometer, 25–50 percent	X	....	X
1	relaxing box, insect	X	X	X

4	rods, Philadelphia	X	X	X
1	sample divider, Boerner	....	X	X
1	sample divider, Gamet	....	X	X
24	sample pans, grain	....	X	X
12	saws, pruning	X	....	X
1	scarifier, seed	....	X	X
1	seed blower, Universal	....	X	X
1	seeder, cone	....	X	X
1	seed separator, air screen laboratory, Ferrell	....	X	X
1	seed separator, dodder mill, Rice	....	X	X
1	seed separator, grader-tester, Simon Carter with 4 Shells	....	X	X
1	seed separator, magnetic, Grisez	....	X	X
1	seed separator, specific gravity, Sutton, Steele and Steele with 3 decks	....	X	X
1	seed separator, spiral, Krussow	....	X	X
1	seed separator, vertical disk, Simon Carter	....	X	X
1	seed splitting machine, for use with vitascope	....	X	X
1	shaker, cylinder	....	X	X
1	shaker, sieve	X	X	X
24	shears, hand pruning, Rieser type	X	....	X
24	shears, lopping	X	....	X
1	sieves, barley (set)	....	X	X
1	sieves, cottonseed (set)	....	X	X
1	sieves, flax (set)	....	X	X
4	sieves, soil analysis (set)	X	X	X
1	sieves, sorghum (set)	....	X	X
1	sieves, soybeans (set)	....	X	X
1	sieves, U. S. Standard (set) (No. 10–20–30–40–60–70–80–100)	X	X	X
1	sieves, wheat, corn, rye, oat (set)	....	X	X
1	sling psychrometer	X	....	X
12	soil augers	X	X	X
24	soil blocks, Bouyoucos	X	X	X
6	soil sample tubes	X	X	X
1	soil test kit, LaMotte-Morgan NPK	X	X	X
3	solubridges, with soil cup	X	X	X
1	sprayer, gasoline powered, 10 gallon	X	X	X
1	sprayer, log plot	X	X	X
4	sprayers, garden, 3 gallon	X	X	X
1	spreader, fertilizer	X	X	X
1	still, distilled water	X	X	X
1	tank, oil storage	X	X	X
1	test unit, water quality	X	X	X
1	thermometer, recording	X	....	X
3	thermometers, Weather Bureau type minimum-maximum	X	....	X
1	thresher, head, model vogel type	....	X	X
2	timers, interval	X	X	X
2	triers, grain (complete lot)	....	X	X
1	triers, seed (complete lot)	....	X	X
1	vitascope (tetrazolium testing of seed for germination)	X	X	X
1	water measuring device, laboratory models (complete set)	X	X	X
1	weight per bushel tester	....	X	X
	Estimated total costs	$30,500 to 32,000	$40,500 to 43,000	$44,500 to 48,000

Suggested Shop Equipment

Quan.	*Item*	*Fruit option*	*Crops option*	*Fruit and crops option*
1	baler, hay	....	X	X
1	battery, charger	X	X	X
1	catching, tray fruit	X	....	X
1	combine	....	X	X
1	crane, overhead power	X	X	X
1	cultivator, corn and vegetable	....	X	X
1	disc, harrow offset	X	X	X
1	disc, harrow tandem	X	X	X
1	ditcher	X	X	X
24	drafting machines	X	X	X
24	drafting tables	X	X	X
1	drill, grain with fertilizer and grass seeding attachment	X	X	X
6	drills, portable	X	X	X
4	drill presses	X	X	X
1	dynamometer, Portable PTO	X	X	X
1	electrical test unit	X	X	X
10	electric motors	X	X	X
1	engine analyzer	X	X	X
10	engines, gasoline and diesel of various sizes, makes, and models	X	X	X
1	forge, gas	X	X	X
6	forks, pitch	X	X	X
6	forks, spading	X	....	X
1	hacksaw, power	X	X	X
1	harrow, coilshank or spring-tooth	X	X	X
1	harrow, spike-tooth	....	X	X
1	harvester, forage	....	X	X

12	hoes, garden	X	X	X
12	hoes, nursery	X	X	X
1	hydraulic press with track pin attachment	X	X	X
1	hydraulic test stand	X	X	X
1	jointer	X	X	X
1	land leveler	X	X	X
6	maddocks	X	X	X
1	mechanical chair	X	....	X
10	meters, volt-ampere	X	X	X
1	micrometer, set	X	X	X
1	mower, hay	....	X	X
1	parts washer	X	X	X
1	picker, corn	....	X	X
6	picks	X	X	X
1	planter, precision	....	X	X
2	planters, row crop or corn	....	X	X
1	plow, disc	....	X	X
4	post hole diggers, hand	X	X	X
4	post hole augers, hand	X	X	X
1	pruners, power	X	....	X
12	rakes, garden	X	X	X
6	rakes, leaves	X	X	X
1	roller, land	....	X	X
1	sander, disk	X	X	X
1	saw, chain	X	....	X
1	saw, chain sharpener	X	....	X
1	saw, portable skill	X	X	X
1	saw, radial arm	X	X	X
12	shovels, round point	X	X	X
12	shovels, square point	X	X	X
1	skip loader, tractor mount	X	X	X
6	soldering guns	X	X	X
6	spades, balling	X	X	X
1	sprayer, orchard mist	X	....	X
1	spreader, fertilizer manure	X	X	X
1	steam cleaner	X	X	X
1	subsoiler	X	X	X
1	sweeper or vacuum	X	....	X
	tools, hand, for:			
	concrete	X	X	X
	carpentry and woodwork	X	X	X
	electrical	X	X	X
	metal, hot and cold	X	X	X
	paint	X	X	X
	plumbing	X	X	X
6	tools, handy man sets	X	X	X
14	tools, mechanic with roller cabinets	X	X	X
1	tool, on panel, master act	X	X	X
6	torches, LPG	X	X	X
1	tractor, row crop 3-point hitch	....	X	X
1	tractor, row crop, small	....	X	X
1	tractor, tracklayer	X	X	X
1	tractor, utility	X	....	X
1	tractor, orchard	X	....	X
1	trailer, field	X	X	X
1	tree shaker, tractor mount	X	....	X
1	truck, 1½-ton stake body	X	X	X
1	truck, pickup	X	X	X
6	weeders, hand	X	X	X
1	welder, 6 station oxy-acty. bench	X	X	X
1	welder, 300 amp. AC–DC units	X	X	X
1	welder, 300 amp. DC portable	X	X	X
1	welder, 300 amp. DC units	X	X	X
5	welders, 220 amp. farm welders	X	X	X
	Estimated total costs	$110,000 to 115,000	$112,000 to 117,000	$145,000 to 160,000

SUMMARY OF COSTS

The following estimates are of the cost of completely supplying and equipping a department for teaching farm crop production technicians at the time of this publication. The estimates are based upon the purchase cost of new and modern equipment and supplies of good quality, but not of the most expensive. **Leasing, renting, or other possible arrangements may significantly reduce these gross figures.** The following assumptions are made:

(1) The program can be started for a lower initial expenditure than the gross estimates shown, but complete plans for, and assurance of obtaining, adequate facilities soon after the program begins will be a part of the institution's policy when initiating any program.

(2) Adequate land for either or both options is assumed to be available, either owned or secured by a long term lease.

(3) Classrooms, laboratories, lecture rooms, library, and other instruction facilities are assumed to be available for all except the technical specialty classes and laboratory work associated with the program. It is assumed that both a drafting room and a chemistry laboratory are available. If a drafting room is not available in the institution, $12,000 (gross estimate) may provide one. Similarly, if a chemistry laboratory is not available for the horticultural soils laboratory work, $25,000 may be used as an estimate of its cost.

(4) No provision is made in this estimate for office furniture, conventional classroom blackboards, student seats, filing cabinets, and the conventional staff or instructor's office equipment.

(5) The estimates assume the availability of a building of suitable construction for the shop and laboratories equipped with normal services, such as electricity, heat, and water to and from the building, but otherwise unfurnished. The cost estimates include piping, wiring, plumbing, and other distribution of services within each facility described.

(6) Cost summaries are provided for each option separately, based on the equipment itemized on preceding pages, so that individual elements in either or both options can be recognized and used for gross prediction of cost of facilities for a program which includes either one of the options or both.

(7) Facilities for each option (and their costs) are provided to accommodate classes of 20 to 25 students per classroom or laboratory. This assumes that there will be two laboratory sections of 10 to 12 students for some parts of the laboratory and shop study.

Forage and Field Crop Option

1 greenhouse (1,000 sq. ft. @ $10 to $12)	$ 10,000	to	12,000
1 lathhouse (500 sq. ft. @ $10 to $12)	5,000	to	6,000
1 head house (2,000 sq. ft. @ $10 to $12)	20,000	to	24,000
audiovisual equipment	2,500	to	3,000
laboratory equipment	40,500	to	43,000
shop equipment	112,000	to	117,000
installation and supplies	8,000	to	10,000
Estimated total cost	$198,000	to	215,000

Fruit and Vine Production Option

1 greenhouse (500 sq. ft. @ $10 to $12)	$ 5,000	to	6,000
1 lathhouse (500 sq. ft. @ $10 to $12)	5,000	to	6,000
1 head house (2,000 sq. ft. @ $10 to $12)	20,000	to	24,000

audiovisual equipment	2,500 to 3,000
laboratory equipment	30,500 to 32,000
shop equipment	110,000 to 115,000
installation and supplies	7,000 to 9,000
Estimated total cost	$180,000 to 195,000

Both Options

2 greenhouses (1,000 sq. ft. @ $10 to $12)	10,000 to 12,000
1 lathhouse (500 sq. ft. @ $10 to $12)	5,000 to 6,000
1 head house (2,000 sq. ft. @ $10 to $12)	20,000 to 24,000
audiovisual equipment	2,500 to 3,000
laboratory equipment	44,500 to 48,000
shop equipment	145,000 to 160,000
installation and supplies	8,000 to 12,000
Estimated total cost	$235,000 to 265,000

The foregoing estimates do not provide for the cost of the building which, if constructed for the program, may be calculated at $14 to $18 per square foot of unfurnished laboratory or shop space; and from $20 to $25 per square foot of furnished laboratory or shop space ready to receive equipment.

BIBLIOGRAPHY

Note.—All first editions which follow are dated; all publications which have gone through one or more revisions or are subject to frequent revision (i.e., handbooks, manufacturer's operator's manuals) are marked "current edition" in order to help those who may order them to always order the most recent published information.

ALBAUGH, RALPH M. *English: A Dictionary of Grammar and Structure.* San Francisco: Chandler Publishing Company, 1964.

ALLARD, R. W. *Principles of Plant Breeding.* New York: John Wiley & Sons, Inc., 1960.

ALLARD, R. W. *and* others. *Manual of California Field Crops.* Berkeley, Calif. University of California Press, Current edition.

The Almanac of The Canning, Freezing, Preserving Industries. 50th ed. Westminster, Md.: Edmund E. Judge Co., 1965.

Aluminum Company of America. *Welding Alcoa Aluminum.* Pittsburgh, Pa.: 1955.

American Society for Metals. *Metals Handbook.* Cleveland: Current edition.

AMERINE, M. A. *and* W. V. CRUESS. *Technology in Winemaking.* Westport, Conn.: AVI Publishing Co., 1965.

ANDERSON, STEPHAN M. *Sanitation for the Food Preservation Industry.* New York: McGraw-Hill Book Co., Inc., 1965.

ANDUS, LESLIE J. *Plant Growth Substances.* New York: John Wiley & Sons, Inc., Current edition.

ARCHER, SELLERS G. *Soil Conservation.* Norman, Oklahoma: University of Oklahoma Press, 1960.

BAIN, READ. *Sociology: Introductory Readings.* Chicago: J. B. Lippincott Co., 1962.

BAIRD, CRAIG A. *and* FRANKLIN H. KNOWER. *Essentials of General Speech.* New York: McGraw-Hill Book Co., Inc., Current edition.

BAKER, SHERIDAN. *The Complete Stylist.* New York: Thomas Y. Crowell Co., 1966.

BARGER, E. L. *Tractors and Their Power Units.* New York: John Wiley & Sons, Inc., 1963.

BARTON, MARY N. Compiler. *A Brief Guide for Students and Other Users of the Library.* Baltimore, Enoch Pratt Free Library, 1947.

BASS, Bernard M. *Leadership, Psychology and Organizational Behavior.* New York: Harper & Brothers, 1960.

BEALS, R. L. *and* HARRY HOIJER. *An Introduction to Anthropology.* New York: The Macmillan Co., 1965.

BEARDSLEY, M. C. *Thinking Straight: Principles of Reasoning For Readers and Writers.* Englewood Cliffs, N.J. Prentice-Hall, Inc., Current edition.

BELLOWS, ROGER. *Psychology of Personnel in Business and Industry.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961.

BENNETT, A. E. *and* LOUIS J. SIY. *Blueprint Reading For Welders.* Albany, N.Y.; Delmar Publishers, Inc., 1966.

BERGER, KERMIT C. *Introductory Soils.* New York: The Macmillan Co., 1965.

BERGMAN, FRED L. *Paragraph Rhetoric: A Program in Composition.* Boston: Allyn & Bacon, Inc., 1967.

BLUMENTHAL, JOSEPH C. *English 2600.* New York: Harcourt, Brace & Co., 1960.

BLUMENTHAL, JOSEPH C. *English 3200.* New York: Harcourt, Brace & World, Inc., 1962.

BOAS, J. *and* others. *General Anthropology.* Boston: D. C. Heath & Co., 1938.

BORROR, D. J. *and* D. M. DELONG. *An Introduction to the Study of Insects.* New York: Rinehart & Co., 1960.

BRADSHAW, L. JACK. *Laboratory Microbiology.* Philadelphia: W. B. Saunders Co., 1963.

BROOKS, CLEANTH, *and* ROBERT PENN WARREN. *Modern Rhetoric.* New York: Harcourt, Brace & World, Inc., 1961.

BROWN, JAMES I. *Efficient Reading.* Revised Edition. Boston: D. C. Heath & Co., 1962.

BROWN, JAMES I. *Programmed Vocabulary.* New York: Appleton-Century-Crofts, 1964.

BROWN, MARION MARSH. *Learning Words in Context.* San Francisco: Chandler Publishing Co., 1961.

BROWN, ARLEN D. *and* IVAN G. MORRISON, *Farm Tractor Maintenance.* Danville, Ill.: The Interstate Printers and Publishers, Inc., 1962.

BRYANT, W. R. *and* JAMES E. HAMILTON. *Profitable Farm Management.* Englewood Cliffs, N. J.: Prentice-Hall, Inc., Current edition.

BUCKLER, W. E. *and* W. C. MCAVOY. *American College Handbook of English Fundamentals.* New York: American Book Co., Current edition.

BUCKMAN, HARRY O. *and* NYLE C. BRADY. *Nature and Properties of Soils.* New York: The Macmillan Co., Current edition.

CANAVAN, JOSEPH *and* WILLIAM O. HECKMAN, *The Way to Reading Improvement.* Boston, Allyn & Bacon, Inc., 1966.

CANAVAN, JOSEPH *and* MARY L. KING. *Developing Reading Skills.* Boston: Allyn & Bacon, Inc., 1968.

CAPP, GLENN R. *How To Communicate Orally.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961.

CASE, H. C. M. *and* others. *Principles of Farm Management.* Chicago: J. B. Lippincott Co., Current edition.

Castle, Emery H. *and* Manning H. Becker. *Farm Business Management*. New York: The Macmillan Co., 1962.

Chandler, William Henry. *Deciduous Orchards*. Philadelphia: Lea & Febiger, Current edition.

Chandler, William Henry. *Evergreen Orchards*. Philadelphia: Lea & Febiger, Current edition.

Chapman, H. D. *and* Parker F. Pratt. *Methods of Analysis for Soils, Plants, and Waters*. Berkeley, Calif.: University of California, Division of Agricultural Sciences, 1961.

Charm, Stanley E. *The Fundamentals of Food Engineering*. Westport, Conn.: AVI Publishing Co., 1963.

Chase, Clinton I., *Elementary Statistics*, New York: McGraw-Hill Book Co., 1967.

Chastain, E. D., Joseph H. Yaeger, *and* E. L. McGraw. *Farm Business Management*. Auburn, Ala.: Auburn Printing Co., 1962.

Cook, G. C. *and* others. *Farm Mechanics Text and Handbook*. Danville, Ill.: The Interstate Printers and Publishers, Current edition.

Cook, R. L. *Soil Management for Conservation and Production*. New York: John Wiley & Sons, Inc., 1962.

Copley, M. J. *and* Wallace B. Van Arsdel. *Food Dehydration*. Vol. II. Westport, Conn.: AVI Publishing Co., 1964.

Cowan, G. *and* E. McPherson. *Plain English Please*. New York: Random House, Inc., 1966.

Crafts, Alden S. *The Chemistry and Mode of Action of Herbicides*. New York: Interscience Publishers, 1961.

Crafts, Alden S. *and* Wilfred W. Robbins. *Weed Control*. New York: McGraw-Hill Book Co., Current edition.

Crandell, Judson S. *and* others. *Speech: A Course in Fundamentals*. Chicago: Scott, Foresman & Co., 1963.

Crouch, W. G. *and* R. L. Zetter. *A Guide to Technical Writing*. New York: The Ronald Press, Current edition.

Cruess, W. V. *Commercial Fruit and Vegetable Products*. New York: McGraw-Hill Book Co., Current edition.

Dalzell, James Ralph. *Building Trades Blueprint Reading*. Chicago: American Technical Society, Current edition.

Darrah, L. B. *Food Marketing*. New York: Ronald Press Co., 1967.

Darrow, G. McM. *Strawberry: History, Breeding, and Physiology*. New York: Holt, Rinehart and Winston, 1966.

Davis, Keith. *Human Relations at Work*. New York: McGraw-Hill Book Co., 1962.

Davis, Theodore F. *Welding and Brazing*. Washington, D.C.: Office of Technical Service, 1960.

Dean, H. H. *and* K. D. Bryson. *Effective Communication*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961.

Delorit, Richard J., *and* Henry L. Ahlgren. *Crop Production*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., Current edition.

DeVitis, A. A. *and* J. R. Warner. *Words in Context: A Vocabulary Builder*. New York: Appleton-Century-Crofts, Current edition.

Di Pippo, Albert E. *From Sentence to Paragraph*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1966.

Dodge, H. *and* H. G.. Romig. *Sampling Inspection Tables—Single and Double Sampling*. New York: John Wiley & Sons, Inc., Current edition.

Donahue, Roy L. *Our Soils and Their Management*. Danville, Ill.: The Interstate Printers and Publishers, Inc., 1961.

Donahue, Roy L. *Soils: An Introduction to Soils and Plant Growth*. Englewood Cliffs, N.J.: Prentice-Hall Co., Inc., Current edition.

Drugger, Roy W. *Getting Started in Irrigation Farming*. Danville, Ill.: The Interstate Printers and Publishers, Inc., 1959.

Duffy, Joseph W. *Power, Prime Mover of Technology*. Bloomington, Ill.: McKnight & McKnight, 1964.

Dull, C. W. *and* others. *Modern Chemistry*. New York: Holt, Rinehart & Winston, Inc., 1962.

Edmond, J. B. *and* others. *Fundamentals of Horticulture*. New York: McGraw-Hill Book Co., Current edition.

Ehlers, Victor M. *and* Ernest W. Steel. *Municipal and Rural Sanitation*. New York: McGraw-Hill Book Co., Current edition.

Eshelman, Philip V. *Tractors and Crawlers*. Chicago: American Technical Society, 1967.

Everett, Edwin M. *and* others. *An Auto-Instructional Text in Correct Writing*. Boston: D. C. Heath & Co., 1964.

Farrall, Arthur W. *Engineering for Dairy and Food Products*. New York: John Wiley & Sons, Inc., 1963.

Feirer, John L. *General Metals*. New York: McGraw-Hill Book Co., 1966.

Ferster, Marilyn Bender. *Programmed College Composition*. New York: Appleton-Century-Crofts, 1965.

Foster, Albert B. *Approved Practices in Soil Conservation*. Danville, Ill.: The Interstate Printers and Publishers, Inc., 1964.

Freeley, Austin J. *Argumentation and Debate*. Belmont, California: Wadsworth Publishing Co., Inc., 1966.

Frey, Paul R. *College Chemistry*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., Current edition.

Friedman, Walter F. *and* Jerome J. Kipness. *Industrial Packaging*. New York: John Wiley & Sons, Inc., 1960.

Frobisher, Martin. *Fundamentals of Microbiology*. Philadelphia: W. B. Saunders Co., Current edition.

Furia, Thomas E. *Handbook of Food Additives*. Cleveland: Chemical Rubber Co., 1968.

Galston, Arthur W. *The Life of The Green Plant*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., Current edition.

Gates, Jean K. *Guide to the Use of Books and Libraries*. New York: McGraw-Hill Book Co., 1962.

Gerber, John. *The Writer's Resource Book*. Glenview, Ill.: Scott, Foresman & Co., Current edition.

Giachino, J. W., *and* others. *Welding Skills and Practices.* Chicago: American Technical Society, 1965.

Giachino, J. W., *and* Neil S. Schoennals. *General Metals for Technology.* Milwaukee: Bruce Publishing Co., 1964.

Gilmer, B. Von Haller. *Applied Psychology.* New York: McGraw-Hill Book Co., 1967.

Graham-Rack, Barry *and* Raymond Brinsted. *Hygiene In Food Manufacturing and Handling.* London, England: Food Trade Press, Ltd., 1964.

Gregg, D. C. *Principles of Chemistry.* Boston: Allyn and Bacon, Inc., Current edition.

Griffin, Ivan H. *and* Edward M. Roden. *Basic Arc Welding.* Albany: Delmar Publishers, Inc., 1962, Current edition.

Griffin, Ivan H. *and* Edward M. Roden. *Basio Tig Welding.* Albany: Delmar Publishers Inc.

Groom, Bernard, *A Short History of English Words.* New York: St. Martin's Press, 1965.

Hall, Carl W. *Processing Equipment for Agricultural Products.* Ann Arbor, Mich.: Edwards Brothers, Inc., 1963.

Hall, I. F. *and* W. P. Mortenson. *The Farm Management Handbook.* Danville, Ill.: The Interstate Printers and Publishers, Inc., Current edition.

Hamilton, J. Roland. *Using Electricity On the Farm.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1959.

Harlan, Jack R. *Theory and Dynamics of Grassland Agriculture.* Princeton, N.J.: D. Van Nostrand, Inc., 1956.

Harris, A. G. *Farm Machinery.* New York: Oxford University Press, 1965.

Harwell, George C. *Technical Communications.* New York: Macmillan Co., 1960.

Hathaway, Dale E. *Government and Agriculture.* New York: Macmillan Co., 1963.

Hathaway, Dale E. *Problems of Progress in the Agricultural Economy.* Chicago: Scott, Foresman & Co., 1963.

Hays, Robert. *Principles of Technical Writing.* Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1965.

Hedges, Trimble R. *Farm Management Decisions.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963.

Hellyer, A. G. L. *Garden Pests and Diseases.* London, England: W. H. and L. Collingstridge, Ltd., 1966.

Hersom, A. C. *and* E. D. Hulland, *Canned Foods, An Introduction To Their Microbiology.* New York: Chemical Publishing Co., Current edition.

Hilgard, Ernest T. *Introduction to Psychology.* New York: Harcourt, Brace, & World, 1962.

Hirshberg, Herbert S. *Subject Guide to Reference Books.* Chicago: American Library Association, 1942.

Hitchcock, A. S. *Manual of the Grasses of the United States.* Washington, D.C.: Government Printing Office, Current edition.

Hodges, John C. *and* Sheila Y. Laws. *Harbrace College Workbook.* New York: Harcourt, Brace & World, Inc., 1967.

Holum, John R. *Elements of General and Biological Chemistry.* New York: John Wiley & Sons, Inc., 1962.

Hook, J. N. *Spelling 1500: A Program.* New York: Harcourt, Brace & World, Inc., 1967.

Hook, J. N. *and* Robert L. Stevens. *Competence in English: A Programmed Handbook.* New York: Harcourt, Brace & World, Inc., 1967.

Hopkins, John A. *and* Earl O. Heady. *Farm Records and Accounting.* Ames, Iowa: Iowa State University Press, Current edition.

Howell, E. L. *Building and Equipping the Farm Shop.* Danville, Ill.: The Interstate Printers and Publishers, Inc., 1958.

Hughes, Harold D. *and* Edwin Henson. *Crop Production Principles and Practices.* New York: The Macmillan Co., 1967.

Hughes, H. D. *and* others. *Forages.* Ames, Iowa: Iowa State University Press, 1962.

Hunt, Donnell. *Farm Power and Machinery Management.* Ames, Iowa: Iowa State University Press, Current edition.

Hutchins, Margaret. *Introduction to Reference Work.* Chicago: American Library Association, 1944.

Industry and Welding Illustrated, *Welding Directory.* Cleveland, Ohio: Industrial Publishing Corp., 1967.

Israelsen, Orson W. *and* Vaughn E. Hansen. *Irrigation Principles and Practices.* New York: John Wiley & Sons, Inc., 1962.

Janick, Jules. *Horticultural Science.* San Francisco: W. H. Freeman & Co., 1963.

Jefferson, T. B. *and* Woods Gorham. *Metals and How to Weld Them.* Cleveland, Ohio: The James F. Lincoln Welding Foundation, Current edition.

Jennings, Harold L. *and* Calvin R. Tracy. *Handbook for Technical Writers.* Chicago: American Technical Society, 1961.

Jones, Fred R. *Farm Gas Engines and Tractors.* New York: McGraw-Hill Book Co., Inc., Current edition.

Jones, Henry D. *and* Louis K. Mann. *Onions and Their Allies.* New York: John Wiley & Sons, Inc., 1963.

Joslyn, Maynard A. *and* J. L. Heid. *Food Processing Operations.* Vols. I, II, III. Westport, Conn.: AVI Publishing Co., 1963.

Judson, Horace. *The Techniques of Reading.* New York: Harcourt, Brace & World, Inc., 1963.

Kalish, Richard L. *Psychology of Human Behavior.* Belmont, Calif.: Wadsworth Publishing Co., 1966.

Kingsbury, John M. *Poisonous Plants of the United States and Canada.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964.

Klingman, Glenn. *Weed Control: As A Science.* New York: John Wiley & Sons, Inc., 1961.

Klotz, Leo J. *Color Handbook of Citrus Diseases.* Berkeley, Calif.: University of California, Division of Agricultural Sciences, 1961.

Knott, James E. *Handbook for Vegetable Growers.* New York: John Wiley & Sons, Inc., Current edition.

Knuti, Leo L. *and* others. *Profitable Soil Management.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962.

Kohls, Richard L. *Marketing of Agricultural Products.* New York: The Macmillan Co., Current edition.

Krech, David *and* others. *Individual in Society.* New York: McGraw-Hill Book Co., Inc., 1962.

Kugler, H. L. *Arc Welding Lessons for School and Farm Shop.* Cleveland: James J. Lincoln Arc Welding Foundation, 1960.

Kurtz, L. O'Dean *and* **Kenton L. Harris.** *Micro-Analytical Entomology for Food Sanitation Control.* Washington, D.C.: Association of Official Agricultural Chemists, 1962.

Laverton, Sylvia. *Irrigation: Its Profitable Use For Agricultural and Horticultural Crops.* New York: Oxford University Press, 1964.

Leedy, Paul D. *Read With Speed and Precision.* New York: McGraw-Hill Book Co., 1963.

Lees, R. *The Laboratory Handbook of Methods of Food Analysis.* Cleveland: Chemical Rubber Co., Current edition.

Legal Requirements of Labeling. Washington, D.C.: National Census Association. Current edition.

Leithold, Louis. *The Calculus.* New York: Harper & Row, 1967.

Leonard, Warren H. *and* **John H. Martin.** *Cereal Crops.* New York: The Macmillan Co., 1963.

Leonard, Warren H. *and* **Dale L. Reeves.** *General Field Crops Laboratory Manual.* Minneapolis: Burgess Publishing Co., Current edition.

Leopold, A. C. *Plant Growth and Development.* New York: McGraw-Hill Book Co., Inc., 1964.

Levens, A. S., *and* **A. E. Edstrom,** *Problems in Mechanical Drawing.* New York: McGraw-Hill Book Co., Inc., 1967.

Lock, Arthur. *Practical Canning.* London, England: Food Trade Press, Ltd., 1960.

Lyman, Taylor. *Metals Handbook.* Cleveland: American Society for Metals, Current edition.

MacGillivray, John H. *Vegetable Production.* New York: McGraw-Hill Book Co., Inc., 1961.

MacGillivray, John H. *and* **Robert A. Stevens.** *Agricultural Labor and Its Effective Use.* Palo Alto, Calif.: The National Press, 1964.

McSwan, I. C., *and* **R. L. Powelson.** *Oregon Plant Disease Control Handbook.* Corvallis, Oregon: Oregon State University Coop. Book Store, 1966.

Marder, Daniel. *The Craft of Technical Writing.* New York: Macmillan Co., 1960.

Martin, Alexander C., *and* **William D. Barkley.** *Seed Identification Manual.* Berkeley, Calif.: University of California Press, 1961.

Martin, John H., *and* **Warren H. Leonard.** *Principles of Field Crop Production.* New York: The Macmillan Co., Current edition.

May, W. Graham. *Foundations of Modern Mathematics.* Waltham, Mass.: Blaisdell Publishing Co., 1967.

Mayer, A. M. *and* **A. Poljakoff-Mayber.** *Germination of Seeds.* Long Island City, New York: Pergamon Press, Inc., 1963.

McBurney, James H. *and* **Glen E. Mills.** *Argumentation and Debate.* New York: The Macmillan Co., 1964.

McCall, Roy C. *and* **Herman Cohen.** *Fundamentals of Speech: The Theory and Practice of Oral Communication.* New York: The Macmillan Co., 1963.

McGee, R. V. *Mathematics in Agriculture.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., Current edition.

Metcalf, C. L., *and* **W. P. Flint,** revised by **R. L. Metcalf.** *Destructive and Useful Insects: Their Habits and Control.* New York: McGraw-Hill Book Co., Inc., Current edition.

Meyer, Lillian. *Food Chemistry.* New York: Reinhold Publishing Co., 1960.

Millar, C. E. *and* others. *Fundamentals of Soil Science.* New York: John Wiley & Sons, Inc., Current edition.

Monroe, Alan H. *Principles and Types of Speech.* Chicago: Scott, Foresman & Co., 1962.

Morris, William E. *Form and Focus: A Rhetorical Reader.* New York: Harcourt, Brace & World, Inc., 1964.

Mortensen, Ernest *and* **Ervin T. Bullard.** *Handbook of Tropical and Subtropical Horticulture.* Washington, D.C.: Department of State, Agency for International Development, Current edition.

Mott, Paul E. *The Organization of Society.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965.

Nechamkin, Howard. *Laboratory Problems Manual of General Chemistry.* New York: Thomas Y. Crowell Co., Current edition.

Neubauer, Loren W., *and* **Harry B. Walker.** *Farm Building Design.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961.

Nitz, O. W. *Introductory Chemistry.* Princeton, N.J.: D. Van Nostrand Co., Inc., Current edition.

Oliver, Robert T. *and* others. *Communicative Speaking and Listening.* New York: Holt, Rinehart & Winston, Inc., 1968.

Olivier, Henry. *Irrigation and Climate: New Aids to Engineering Planning and Development of Water Resources.* New York: St. Martins Press, 1962.

The Oxy-Acetylene Handbook. New York: Union Carbide Corp., 1967.

Palmer, Raymond C. *The English Sentence: A Programed Course.* San Francisco: Chandler Publishing Co., 1966.

Parker, Marvin M. *Farm Welding.* New York: McGraw Hill Book Co., Inc., Current edition.

Pauling, Linus. *College Chemistry.* San Francisco: W. H. Freeman & Co., 1964.

Pearson, Lorentz C. *Principles of Agronomy.* New York: Reinhold Publishing Co., 1966.

Perrin, Porter G. *and* **G. H. Smith.** *Handbook of Current English.* Glenview, Ill.: Scott, Foresman & Co., 1962.

Pfadt, R. E., editor. *Fundamentals of Applied Entomology.* New York: The Macmillan Co., 1962.

Phillips, Arthur L., editor. *Welding Handbook.* New York: American Welding Society, 1963.

Phipps, Lloyd J. *Mechanics in Agriculture.* Danville, Ill.: The Interstate Printers and Publishers, Inc., 1967.

Pipe, Ted. *Small Gasoline Engines Training Manual.* New York: The Bobbs-Merrill Co., Inc., 1966.

Preserver's Handbook. Ontario, Calif.: California Fruit Growers Exchange, Current edition.

Promersberger, William *and* F. Bishop, *Modern Farm Power*. New York: Prentice-Hall, Inc., 1962.

Quagliano, J. V. *Chemistry*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963.

Rau, Hans. *Solar Energy*. New York: The Macmillan Co., 1964.

Rees, Paul K. *Principles of Mathematics*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965.

Rice, Harold S., *and* Raymond M. Knight. *Technical Mathematics and Calculus*. New York: McGraw-Hill Book Co., Inc., Current edition.

Richards, Frances M. *and* Jack S. Romine. *Word Mastery*. Dubuque, Iowa: Wm. C. Brown Co., Publishers, 1963.

Richey, C. B. *and* others. *Agricultural Engineers' Handbook*. New York: McGraw-Hill Book Co., Current edition.

Roget, Peter, ed. by N. Lewis. *New Roget's Thesaurus in Dictionary Form*. New York: G. P. Putnam's Sons, 1965.

Rogge, Edward *and* James C. Ching. *Advanced Public Speaking*. New York: Holt, Rinehart & Winston, Inc., 1966.

Routh, Joseph I. *Fundamentals of Inorganic, Organic and Biological Chemistry*. Philadelphia: W. B.. Saunders Co., Current edition.

Roy, Ervell P. *Contract Farming U. S. A.* Danville, Ill.: The Interstate Printers and Publishers, 1963.

Rubey, Harry. *Supplemental Irrigation for Eastern United States*. Danville, Ill.: The Interstate Printing and Publishing, Inc., 1963.

Russell, John B. *Study Guide for Sienko and Plane Chemistry*. New York: McGraw-Hill Book Co., Inc., Current edition.

Ruttan, Vernon W. *Economic Demand For Irrigated Acreage*. Baltimore: John Hopkins Co., 1965.

Sachs, H. J. *and* others. *A Workbook for Writers*. New York: American Book Co., 1960.

Sanderson, R. T. *Principles of Chemistry*. New York: John Wiley & Sons, Inc., 1963.

Scheer, Arnold H., *and* Elwood M. Juergenson. *Approved Practices in Fruit Production*. Danville, Ill.: The Interstate Printing & Publishing, Inc., 1964.

Schneider, G. W., *and* C. C. Scarborough. *Fruit Growing*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1960.

Schultz, Theodore W. *Economic Crises in World Agriculture*. Ann Arbor, Mich.: University of Michigan Press, 1965.

Schutte, William M., *and* E. R. Steinberg. *Communication in Business and Industry*. New York: Holt, Rinehart, & Winston, 1960.

Seferian, Daniel. *Metallurgy of Welding*. New York: John Wiley & Sons, 1962.

Sheff, Alexander L. *Bookkeeping Made Easy*. New York: Barnes & Noble, Inc., 1966.

Shepherd, D. G. *Introduction to the Gas Turbine*. New York: D. Van Nostrand Co., Inc., 1960.

Sherbourne, Julia F. *Toward Reading Comprehension*. Boston: D. C. Heath & Co., 1966.

Shippen, J. M., *and* J. C. Turner. *Basic Farm Machinery*, Vol. I. New York: Pergamon Press, 1966.

Shoemaker, James S. *Small Fruit Culture*. New York: McGraw-Hill Book Co., Inc., Current edition.

Shores, Louis. *Basic Reference Sources: An Introduction to Materials and Methods*. Chicago: American Library Association, 1954.

Shuster, Robert L., *and* James M. Reid, Jr. *A Program for Effective Writing*. New York: Appleton-Century-Crofts, 1966.

Shurtleff, M. C. *How To Control Plant Diseases in Home and Garden*. Ames, Iowa: The Iowa State University Press, 1962.

Sienko, M. J., *and* R. A. Plane. *Chemistry: Principles and Properties*. New York: McGraw-Hill Book Co., Inc., 1966.

Sinclair, W. B. editor. *The Orange: Its Biochemistry and Physiology*. Berkeley, Calif.: University of California, Division of Agricultural Sciences, 1961.

Slocum, Walter L. *Agricultural Sociology*. New York: Harper & Brothers, 1962.

Smith, Genevieve Love. *A Programmed Test: Spelling by Principles*. New York: Appleton-Century-Crofts, 1966.

Smith, Harris P. *Farm Machinery and Equipment*. New York: McGraw-Hill Book Co., Inc. Current edition.

Snodgrass, Milton M., *and* Luther L. Wallace. *Agriculture Economics and Growth*. New York: Appleton-Century-Crofts, 1964.

Society of Automotive Engineers. *Engineering Know-How In Engine Design*. New York: Society of Automotive Engineers, 1962.

Sosnin, H. A. *Arc Welding Instructions for the Beginner*. The James F. Lincoln Arc Welding Foundation, 1964.

Steward, F. C. *Plants at Work*. Reading, Mass.: Addison-Wesley Publishing Co., Inc., 1964.

Steward, M. M. *and* others. *Business English and Communication*. New York: McGraw-Hill Book Co., Current edition.

Strunk, William Jr., *The Elements of Style*. New York: The Macmillan Co., 1962.

Sullivan, M. W. *Programmed Grammar*. New York: McGraw-Hill Book Co., 1964.

Taylor, C. Fayette. *The Internal Combustion Engine*. Scranton, Pa.: International Textbook Co., 1961.

Taylor, Lee, *and* Arthur Jones, Jr. *Rural Life and Urbanized Society*. New York: Oxford Press, 1964.

Thompson, Homer C., *and* William C. Kelley, *Vegetable Crops*. New York: McGraw-Hill Book Co., Inc., Current edition.

Thompson, W. N. *Fundamentals of Communication*. New York: McGraw-Hill Book Co., 1957.

Tisdale, Samuel L., *and* Werner L. Nelson. *Soil Fertility and Fertilizers*. New York: The Macmillan Co., Current edition.

Tressler, Donald K. and Clifford F. Evers. *The Freezing Preservation of Foods*, Vol. I,II. Westport, Conn.: AVI Publishing Co., Current edition.

Tressler, Donald K. and Maynard A. Joslyn. *Fruit and Vegetable Juice Processing Technology*. Westport, Conn.: AVI Publishing Co., 1961.

United States Standard for Grades. Washington, D.C.: U.S. Department of Agriculture, Fruit and Vegetable Division. Current edition.

U.S. Department of Agriculture. *Consumers All*. (Yearbook of Agriculture, 1965) Washington, D.C.: Government Printing Office, 1965.

U.S. Department of Agriculture. *Financial Calculations and Physical Measurements*. Agriculture Handbook. 230 Washington, D.C.: U.S. Government Printing Office, 1964.

U.S. Department of Agriculture. *Protecting Our Food*. (Yearbook of Agriculture, 1966). Washington, D.C.: Government Printing Office, 1966.

U.S. Department of Agriculture. *Agricultural Marketing*. (A monthly periodical)

U.S. Department of Agriculture. *Manual for Testing Agriculture and Vegetable Seeds*. Washington, D.C.: Government Printing Office, 1952.

U.S. Department of Agriculture. *Summary of Registered Pesticide Uses*. Washington, D.C.: Government Printing Office, Current edition.

U.S. Department of Health, Education, and Welfare, Office of Education. *Chemical Technology A*. OE–80027 Washington, D.C.: U.S. Government Printing Office, Supt. of Documents, 1967.

U.S. Department of Health, Education, and Welfare, Office of Education. *Food Processing Technology, A Suggested 2-year Post High School Curriculum*. OE–80027 Washington, D.C.: U.S. Government Printing Office, Supt. of Documents, 1967.

U.S. Department of Health, Education, and Welfare, Office of Education. *Scientific and Technical Societies Pertinent to the Education of Technicians*. OE–80027 Washington, D.C.: U.S. Government Printing Office, Supt. of Documents, 1965.

U.S. Department of Health, Education, and Welfare. Office of Education. *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs*. Washington, D.C.: U.S. Government Printing Office, 1962.

U.S. Department of Health, Education, and Welfare. Office of Education. *Pretechnical Post High School Programs, A Suggested Guide*. Washington, D.C.: U.S. Government Printing Office, 1967.

Van Arsdel, Wallace B. *Food Dehydration*. Vol. I. Westport, Conn.: AVI Publishing Co., 1964.

Vincent, Warren H. *Economics and Management in Agriculture*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962.

Wallace, James J., and Raymond R. Benke. *Managing the Tenant-Operated Farm*. Ames, Iowa: Iowa State Press, Current edition.

Weisz, Paul B., and Melvin S. Fuller, *The Science of Botany*. New York: McGraw-Hill Book Co., Inc., 1962.

Welding and Cutting Manual. New York: Union Carbide Corp., 1966.

Westcott, Cynthia. *Gardener's Bug Book*. Garden City, N.Y.: Doubleday & Co., Current edition.

Westcott, Cynthia. *Plant Disease Handbook*. New York: D. Van Nostrand Co., Inc., Current edition.

Whitaker, T. W., and G. N. Davis, *Cucurbits*. New York: John Wiley & Sons, Inc., 1962.

White, C. M. and others. *Sources of Information in the Social Sciences*. Totowa, N.J.: The Bedminster Press, 1964.

Wilcox, Walter W. and Willard W. Cochrane, *Economics of American Agriculture*. Englewood Cliffs, N.J.: Prentice-Hall, 1960.

Willis, Hulon. *Structural Grammar and Composition*. New York: Holt, Rinehart & Winston, Inc., 1967.

Wilson, Kenneth G., and others. *Harbrace Guide to Dictionaries*. New York: Harcourt, Brace & World, Inc., 1963.

Winchell, Constance M. *Guide to Reference Books*. Chicago: American Library Association, 1951.

Winkler, A. J. *General Viticulture*. Berkeley, California: University of California Press, 1962.

Woolrich, Willis Raymond. *Handbook of Refrigeration Engineering*. Westport, Conn.: AVI Publishing Co., Current edition.

Wood, Jesse H. and Charles W. Kennan. *General College Chemistry*. New York: Harper & Row, 1961.

Zetler, Robert L., and W. G. Crouch. *Successful Communication In Science and Industry*. New York: McGraw-Hill Book Co., 1961.

Zimmerman, Josef D. *Irrigation*. New York: John Wiley & Sons, Inc. 1966.

APPENDIX

Selected List of Professional and Technical Societies and Organizations Concerned with Crop and Fruit Production

A list of some professional and technical societies and associations concerned with crop and fruit production can be a source of useful instructional information and reference data. The compendium which follows is not a complete listing; inclusion does not imply special approval; omission does not imply disapproval of an organization. Details regarding local chapters or sections have been omitted. Educators desiring information from the organizations may address inquiries to the executive secretary at the address shown.

AGRICULTURAL AIRCRAFT ASSOCIATION, 524 West Kearney Boulevard, Chandler Field, Fresno, Calif. 93706.

Purpose: Owners or operators of agricultural aircraft businesses.

Publications: *Newsletter*. Also publishes safety bulletins.

AGRICULTURAL RESEARCH INSTITUTE, c/o National Academy of Science, 2101 Constitution Avenue N.W., Washington, D.C. 20418.

Purpose: To promote research and policies to insure best utilization of agricultural resources in the national economy. Affiliated with the Agricultural Board and sponsored by National Research Council.

Publications: Various Research Reports.

AMERICAN ENTOMOLOGICAL SOCIETY, 1900 Race Street, Philadelphia, Pa. 19103.

Purpose: To promote the study of insects and to publish results of pure research in the systematics and morphology of insects.

Publications: *Entomological News*, 10 times a year; *Transactions*, quarterly; *Memoirs*, irregular.

AMERICAN FARM RESEARCH ASSOCIATION, 100 Willayne Plaza, 402 Northwestern Avenue, West Lafayette, Ind. 47906.

Purpose: To direct work in animal and plant nutrition, seed and farm chemicals, and farm fields and lubricants.

Publications: None.

AMERICAN HORTICULTURAL SOCIETY, 1600 Bladensburg Road N.E., Washington, D.C. 20002.

Purpose: Membership includes individual amateur and professional gardeners.

Publications: *AHS Gardeners' Forum*, 8 times year; *American Horticultural Magazine*, quarterly.

AMERICAN MUSHROOM INSTITUTE, P.O. Box 373, Kennett Square, Pa. 19348.

Purpose: To Conduct promotion campaign to increase consumption of mushrooms.

Publications: *Mushroom News*, monthly.

AMERICAN POMOLOGICAL SOCIETY, Department of Horticulture, Michigan State University, East Lansing, Mich. 48823.

Purpose: To provide information to professional and amateur horticulturists.

Publications: *Fruit Varieties and Horticultural Digest*, quarterly.

AMERICAN POTASH INSTITUTE, 1102 16th Street, N.W., Washington, D.C. 20036.

Purpose: To conduct scientific research program in agricultural use of potash.

Publications: *Better Crops with Plant Food*, bimonthly.

AMERICAN RICE GROWERS COOPERATIVE ASSOCIATION, 211 Pioneer Building, Lake Charles, La. 70601.

Purpose: Federation of local farmers' cooperatives engaged in processing, storage and marketing of rough rice.

Publications: None.

AMERICAN SEED TRADE ASSOCIATION, Southern Building, 15th and K Street N.W., Suite 803, Washington, D.C. 20005.

Purpose: Breeders, growers, assemblers, conditioners, wholesalers, retailers of grain, grass, vegetable, and flower seeds.

FEDERATED PECAN GROWERS' ASSOCIATION OF THE UNITED STATES, P.O. Box 8597, Baton Rouge, La. 70803.

Purpose: Federation of regional pecan growers' associations.
Publications: None.

FLORIDA CITRUS MUTUAL, P.O. Box 499, Lakeland, Fla. 33802.
Purpose: Citrus growers' organization supplying market and price information and promotional materials to its members.
Publications: *Triangle*, weekly; *Market Bulletin*, 4/week.

FLORIDA FRESH CITRUS SHIPPERS, ASSOCIATION, P.O. Box 113, Lakeland, Fla. 33802.
Purpose: Shippers of fresh Florida citrus fruits.
Publications: None.

FLORIDA LYCHEE GROWERS' ASSOCIATION, P.O. Box 7, Laurel, Fla. 33545.
Purpose: Marketing organization of lychee growers.
Publications: Yearbook.

FLORIDA MANGO FORUM, 1102 North Krome Avenue, Homestead, Fla. 33030.
Purpose: To promote the study of mango production, marketing, and selection of new varieties.
Publications: *Proceedings*, annual.
Publication: Yearbook.

AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE, 301 Horticulture Building, Michigan State University, East Lansing, Mich. 48823.
Purpose: To promote and encourage national interest in scientific research and education in horticulture.
Publications: *Newsletter*, semiannual; Proceedings (2nd volume includes roster), semiannually.

AMERICAN SOCIETY OF AGRONOMY, 677 South Segoe Road, Madison, Wis. 53711.
Purpose: Professional society concerned with farm crops and soils and conditions affecting them.
Publications: *Agronomy Journal*, bimonthly; *Crops and Soils*, 9 times a year.

AMERICAN SOCIETY OF ENOLOGISTS, Department of Viticulture and Enology, University of California, Davis, Calif. 95616.
Purpose: To promote technical advancement in enology through integrated research by science and industry.
Publications: *Journal of Enology and Viticulture*, quarterly; *News Edition*, quarterly.

AMERICAN SOCIETY OF RANGE MANAGEMENT, P.O. Box 13302, Portland, Ore. 97213.
Purpose: Professional society concerned with range management.
Publications: *Journal of Range Management*, bimonthly.

AMERICAN SOYBEAN ASSOCIATION, Hudson, Iowa 50643.
Purpose: To promote new varieties of soybeans and new markets in the United States and abroad; to combat diseases and insect pests affecting production.
Publications: *Soybean Digest*, monthly; *Soybean Blue Book*, annual; *Late News*, 32 issues year.

AMERICAN SUGAR CANE LEAGUE OF THE U.S.A., Whitney Boulevard, New Orleans, La. 70130.
Purpose: Organization for sugar cane producers.
Publications: None.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, Box 540, Benjamin Franklin Station, Washington, D.C., 20044.
Purpose: To provide information for chemists who develop, test and sponsor improved methods of analyzing products related to agricultural commodities.
Publications: *Journal of the AOAC*, bimonthly. Publishes official methods of analysis of the AOAC every 5 years.

ASSOCIATION OF OFFICIAL SEED ANALYSTS, 325 U.S. Court House, Kansas City, Mo. 64106.
Purpose: To provide information for officials of 68 Federal, State, seed testing and research laboratories.
Publications: *Newsletter*, quarterly; *Proceedings*, annual; *Rules for testing seed*, 5 issues a year.

BEET SUGAR DEVELOPMENT FOUNDATION, 156 South College, P.O. Box 538, Fort Collins, Colo. 80521.
Purpose: To conduct and promote research on beet sugar processing and sugar beet improvement.
Publications: None.

CALAVO GROWERS OF CALIFORNIA (Avocado), 4833 Everett Avenue, Los Angeles, Calif. 90058.
Purpose: Activities include packing, promotion, and marketing of and research on avocados and other specialty fruits (fresh).
Publications: *Newsletter*, semimonthly; *Calavo News*, irregular.

CALIFORNIA ALMOND GROWERS EXCHANGE, P.O. Box 1768, Sacramento, Calif. 95808.
Purpose: To promote sale of almonds on domestic and foreign markets, encourage correct almond cultural practices, and develop stronger and specialized almond strains.
Publications: *Almond Facts*, bimonthly.

CALIFORNIA DATE GROWERS ASSOCIATION, P.O. Box 577, Indio, Calif. 92201.
Purpose: To promote cooperative marketing and harvesting.
Publications: None.

CALIFORNIA FIG INSTITUTE, P.O. Box 709, Fresno, Calif. 93712.
Purpose: To promote research programs for commercial fig growers in California (only State producing figs).
Publications: *Statistical Review*, annual.

CALIFORNIA FRUIT EXCHANGE, 1400 10th Street, Sacramento, Calif. 95814.

Purpose: Cooperative marketing organization to distribute deciduous tree fruits and table grapes.
Publications: *Blue Anchor*, quarterly.

CALIFORNIA GRAPE AND TREE FRUIT LEAGUE, 717 Market Street, San Francisco, Calif. 94103.
Purpose: To provide information for growers and shippers of fresh deciduous tree fruits, grapes, berries in California and Arizona.
Publications: *Newsletter*, irregular.

CALIFORNIA RAISIN ADVISORY BOARD, 2240 North Angus Avenue, Fresno, Calif. 93726.
Purpose: To promote the sale of raisins and raisin products.
Publications: *Report to Raisinlanders*, annual.

CALIFORNIA STRAWBERRY ADVISORY BOARD, c/o Malcolm B. Douglas, P.O. Box 57, Santa Clara, Calif. 95052.
Purpose: No data found.
Publications: None.

CHERRY GROWERS AND INDUSTRIES FOUNDATION, Box 283, Salem, Ore. 97308.
Purpose: To provide information for growers, processors, and shippers of cherries.
Publications: None.

COUNCIL FOR AGRICULTURAL AND CHEMURGIC RESEARCH, 350 Fifth Avenue, New York, N.Y. 10001.
Purpose: To promote discovery of new nonfood uses for farm crops, their residues and byproducts; new crops that farmers may grow profitably, etc.
Publications: *Chemurgic Digest*, 8 issues a year.

CRANBERRY INSTITUTE, South Duxbury, Mass. 02374.
Purpose: To promote research on production and marketing of cranberries.
Publications: None.

CROP PROTECTION INSTITUTE, P.O. Box 5, Durham, N.H. 03824.
Purpose: To conduct biological and biocidal research and development of insecticides, herbicides, fungicides, nematocides, etc.
Publications: None.

CROP QUALITY COUNCIL, 828 Midland Band Boulevard, Minneapolis, Minn. 55401.
Purpose: To encourage research and control of pests affecting food, feed, oil, and forage crops.
Publications: None.

CROP SCIENCE SOCIETY OF AMERICA, 667 South Segoe Road, Madison, Wis. 53711.
Purpose: To advance research, extension, and teaching of all basic phases of the crop sciences and to cooperate with all other organizations similarly interested in the improvement, production, management, and utilization of field crops.
Publications: *Crop Science*, bimonthly.

DATE GROWERS' INSTITUTE, Route 2, Box 81, Thermal, Calif. 92274.
Purpose: To provide information for commercial growers of dates.
Publications: DGI Bulletin annual.

DIAMOND WALNUT GROWERS, 1050 South Diamond Street, Stockton, Calif. 95205.
Purpose: Producers' processing and marketing organization.
Publications: *Diamond Walnut News*, bimonthly.

ENTOMOLOGICAL SOCIETY OF AMERICA, 5603 Calvert Road, College Park, Md. 20740.
Purpose: Professional society of entomologists and others interested in the study and control of insects.
Publications: *Annals of E.S.A.*, bimonthly; *Journal of Economic Entomology*, bimonthly; Miscellaneous publications of E.S.A., irregular; *Bulletin of E.S.A.*, quarterly.

FARM EQUIPMENT INSTITUTE, 608 South Dearborn Street, Chicago, Ill. 60605.
Purpose: To provide information for manufacturers of farm implements, machinery, and equipment.
Publications: *FEI Letter*, bimonthly; *Farm Equipment Industry Facts*, annual; *Land of Plenty*. Survey of Agricultural Engineering Projects at Land Grant Colleges in the United States, Canada, Puerto Rico.

FARM EQUIPMENT MANUFACTURERS ASSOCIATION, 34 North Brentwood, St. Louis, Mo. 63105.
Purpose: To serve manufacturers of "short lines" of specialized farm equipment.
Publications: *Shortliner*, semimonthly.

FARM FILM FOUNDATION (Motion Pictures), 1425 H Street N.W., Washington, D.C. 20005.
Purpose: To create better understanding between urban and rural America through audiovisual education.
Publications: Catalog of 16mm motion pictures.

FEDERATED PECAN GROWERS' ASSOCIATIONS OF THE UNITED STATES, P.O. Box 8597, Baton Rouge, La. 70803.
Purpose: Federation of regional pecan growers' associations.
Publications: None:

FLORIDA CITRUS MUTUAL, P.O. Box 499, Lakeland, Fla. 33802.
Purpose: Citrus growers' organization supplying market and price information and promotional materials to its members.
Publications: *Triangle*, weekly; *Market Bulletin*, 4/week.

FLORIDA FRESH CITRUS SHIPPERS' ASSOCIATION, P.O. Box 113, Lakeland, Fla. 33802.
Purpose: Shippers of fresh Florida citrus fruits.
Publications: None.

FLORIDA LYCHEE GROWERS' ASSOCIATION, P.O. Box 7, Laurel, Fla. 33545.
Purpose: Marketing organization of lychee growers.
Publications: Yearbook.

FLORIDA MANGO FORUM, 1102 North Krome Avenue, Homestead, Fla. 33030.
Purpose: To promote the study of mango production, marketing, and selection of new varieties.
Publications: *Proceedings*, annual.

HAWAIIAN SUGAR PLANTERS' ASSOCIATION, P.O. Box 2450, Honolulu, Hawaii. 96804.
Purpose: To improve and protect the sugar industry of Hawaii; to support an experiment station.
Publications: *Hawaiian Planters' Record*, annual.

INTERNATIONAL COTTON ADVISORY COMMITTEE, 5441 South Building, Department of Agriculture, Washington, D.C. 20250.
Purpose: To collect and disseminate statistics on world cotton situation, production, trade, consumption, stocks; to suggest to represented governments ways of maintaining a stable cotton economy.
Publications: *Cotton, Monthly Review; Cotton,* Quarterly Statistical Bulletin; *Proceedings of Plenary Meetings,* annual; *Base Book of Cotton Statistics,* 1959–63.

INTERNATIONAL CROP IMPROVEMENT ASSOCIATION (Seed), c/o R. H. Garrison, Clemson, S.C. 29631.
Purpose: Organization of state seed certifying agencies; promotes breeding, production, and distribution of foundation, registered, and certified seed stocks.
Publications: None.

INTERNATIONAL PLANT PROPAGATORS' SOCIETY, Plant Science Department, University of Connecticut, Storrs, Conn. 06268.
Purpose: To serve commercial nurserymen, plant propagators, teachers and research workers concerned with plant propagation.
Publications: *Proceedings*, annual.

LEMON ADMINISTRATIVE COMMITTEE, 117 West Ninth Street, Room 905, Los Angeles, Calif. 90015.
Purpose: Committee participates in the marketing of fresh lemons in the United States and Canada.
Publications: *Weekly Newsletter.*

NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION, 1145 19th Street N.W., Washington, D.C. 20036.
Purpose: To conduct research to discover new chemicals, improve quality, promote safety in agricultural uses for chemicals.
Publications: *NAC News,* bimonthly; Bulletins and manuals.

NATIONAL ASSOCIATION GREENHOUSE VEGETABLE GROWERS, 1314 Schofield Building, 2014 East Ninth Street, Cleveland, Ohio. 44115.
Purpose: To inform people interested in all aspects of greenhouse vegetable production.
Publications: None.

NATIONAL ASSOCIATION OF WHEAT GROWERS, Room 1128, 1411 K Street N.W., Washington, D.C. 20005.
Purpose: To coordinate the efforts of a federation of 10 State wheat growers' associations.
Publications: *Proceedings,* annual.

NATIONAL CONTAINER COMMITTEE, 22 West Madison Street, Chicago, Ill. 60602.
Purpose: To serve railroads with an interest in damage prevention and development of regulations in regard to fresh fruit and vegetable shipping containers.
Publications: None.

NATIONAL FERTILIZER SOLUTION ASSOCIATION, 1146 Jefferson Building, Peoria, Ill. 61602.
Purpose: To serve manufacturers, wholesalers, dealers, in fertilizer solutions.
Publication: *Solutions,* bimonthly.

NATIONAL JUNIOR VEGETABLE GROWERS ASSOCIATION, P.O. Box 603, North Amherst, Mass. 01002.
Purpose: To conduct educational program for young people (14 to 21) interested in horticulture.
Publications: *NJVGA Newsletter,* irregular.

NATIONAL ONION ASSOCOATION, 201½ East Grand River, East Lansing, Mich. 48823.
Purpose: To compile monthly statistical reports of stock-in-hand, acreage, yield, and production of onions in the United States.

NATIONAL PLANT FOOD INSTITUTE (fertilizers), 1700 K Street N.W., Washington, D.C. 20066.
Purpose: To support agricultural research program for fertilizers and dissemination of findings.
Publications: *Plant Food Review,* quarterly; *Regional Plant Food Bulletins.*

NATIONAL SOYBEAN CROP IMPROVEMENT COUNCIL, 211 South Race Street, Urbana, Ill. 61801.
Purpose: To promote growing of soybeans in the United States.
Publications: *Soybean News,* 3 times a year; *Soybean Farming* (booklet).

NORTH AMERICAN BLUEBERRY COUNCIL, P.O. Box 448, South Haven, Mich. 49090.
Purpose: Formed to act as a clearinghouse for research and development activities in blueberry production as well as provide a central publicity and promotion agency for all production areas.
Publications: None.

NORTHERN NUT GROWERS' ASSOCIATION, 4518 Holston Hills Road, Knoxville, Tenn. 37914.

Purpose: To inform commercial growers and others interested in propagation and culture of hardy nut trees.

Publications: *Nutshell*, quarterly; *Proceedings*, annual.

PAN AMERICAN TUNG RESEARCH AND DEVELOPMENT LEAGUE, P.O. Box 73, Poplarville, Miss. 39470.

Purpose: To sponsor and conduct market, product, and scientific research on tung oil and tung byproducts.

Publications: *American Tung Oil Topics*, irregular.

POTATO ASSOCIATION OF AMERICA, New Jersey Agricultural Experiment Station, New Brunswick, N.J. 08903.

Purpose: To inform professionals interested in the Irish (white) potato.

Publications: *American Potato Journal*, monthly; *Potato Handbook*, annual.

PRODUCE PACKAGING ASSOCIATION, P.O. Box 29, Newark, Del. 19711.

Purpose: To improve methods of packaging and marketing produce, fresh fruits and vegetables.

Publications: *Produce Packager*, semimonthly.

RESEARCH AND DEVELOPMENT ASSOCIATES, FOOD AND CONTAINER INSTITUTE, 1819 West Pershing Road, Chicago, Ill. 60609.

Purpose: To inform industrial firms, educational institutions, and related groups engaged in food and container research and development.

Publications: *Activities Report*, quarterly; *Newsletter*, bimonthly. Also publishes technical booklets and reports.

SEED PEA GROUP, 333 North Michigan Avenue, Chicago, Ill. 60601.

Purpose: To serve processors of pea seed sold to the canning trade and suppliers to seed trade.

Publications: None.

SOIL CONSERVATION SOCIETY OF AMERICA, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021.

Purpose: To serve professional soil and water conservationists and others in related fields.

Publications: *Journal of Soil and Water Conservation*, bimonthly. Also monographs, booklets, etc.

SOIL SCIENCE SOCIETY OF AMERICA, 677 South Segoe Road, Madison, Wis. 53711.

Purpose: To serve professional soils workers interested in fundamental and applied soil science.

Publications: *SSSA Proceedings*, bimonthly.

SUGAR RESEARCH FOUNDATION, 52 Wall Street, New York, N.Y. 10005.

Purpose: To study uses of sugar and its byproducts.

Publications: None.

SUNKIST GROWERS (citrus fruit), 707 West Fifth Street, Los Angeles, Calif. 90017.

Purpose: Citrus fruit cooperative for marketing.

Publications: None.

SUN-MAID RAISIN GROWERS OF CALIFORNIA, 2902 Hamilton Avenue, Fresno, Calif. 93721.

Purpose: Cooperative marketing association of raisin growers.

Publications: *Newsletter*, monthly.

SUNSWEET GROWERS (fruit), Market and San Antonio Streets, San Jose, Calif. 95113.

Purpose: Cooperative marketing organization for producers of dried prunes, apricots, peaches, and pears.

Publications: *Sunsweet Standard*, monthly.

TOBACCO INSTITUTE, 808 17th Street N.W., Washington, D.C. 20006.

Purpose: To promote better public understanding of the tobacco industry.

Publications: *Tobacco News*, quarterly; *Tobacco and Health*, quarterly.

UNITED FRESH FRUIT AND VEGETABLE ASSOCIATION, 777 14th Street N.W., Washington, D.C. 20005.

Purpose: To serve growers, shippers, workers, wholesalers, distributors, retailers, handling fresh fruits and vegetables.

Publications: *United Fresh Outlook*, weekly; *United Spudlight*, weekly; *Supply Letter*, monthly; *SWD Bulletin*, monthly; *U. M. I. Fresh Forum*, monthly; *Terminal Times*, monthly; *Nutrition Notes*, quarterly, Yearbook, many special reports.

UNITED STATES NATIONAL COMMITTEE, INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE, P.O. Box 15326, Denver, Colo. 80215.

Purpose: To inform engineers, scientists, and others, interested in irrigation and drainage.

Publications: *Newsletter*, quarterly.

WEED SOCIETY OF AMERICA, Agronomy Dept., University of Illinois, Urbana, Ill. 61801.

Purpose: Professional society of biological and chemical scientists and engineers involved in weed control research, etc.

Publications: *Weeds*, quarterly.

WESTERN AGRICULTURAL CHEMICALS ASSOCIATION, 2466 Kenwood Avenue, San Jose, Calif. 95128.

Purpose: To provide information to a regional organization of producers and formulators of basic pesticide chemicals, etc.

Publications: *Newsletters*, 45/year.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1970 O—355-760